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Final Report

Needs Assessment for Training and Certification Within the Photovoltaic Industry

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ABSTRACT

Photovoltaic generating systems that operate in parallel with the utility grid, and the workforce that specializes in their installation, are little over twenty years old. This workforce is a hybrid mix of scientific researchers, construction trades, architectural designers, new corporate ventures, and tinkering off-grid cultural separatists. This study seeks to assess the state of the knowledge base in the installer community that has evolved to serve the needs of this emerging industry, and to assess the need for and benefits or disadvantages of formal training and certification. The report summarizes surveys of the distribution company personnel that approve interconnections to the grid, the building and electrical inspectors that approve the customer-side-of-the-meter installations, and the installers that perform the actual work. In addition we have reviewed the academic and professional literature surrounding training and certification, and have studied similar industries as they deal with the issues of workforce competency, training, and credentialing. We have concluded that licensure law affecting electrical installations in Massachusetts limits the immediate value of voluntary certification of PV installers. Nonetheless we feel that a phased approach, with the goal of adoption of a program of PV installer training and certification, is warranted for long term benefits.

Keyword:

Competence, Certificate, Certification, License, Accreditation, Photovoltaic, Photovoltaic System Installer, Workforce Training, North American Board of Certified Energy Practitioners (NAPCEP), Great Lakes Renewable Energy Association (GLREA), Institute of Sustainable Power (ISP), Utility Distribution Company, Electrical Inspectors, Building Inspectors, Building Commissioners.

1.0 EXECUTIVE SUMMARY[1]

There are two objectives of this study. The first is to assess the need for training and certification of photovoltaic system installers in Massachusetts to ensure that PV systems are properly designed, sited and installed. The second objective is to assess the level of training and understanding required of utility personnel and local inspectors to properly evaluate and approve photovoltaic installations. This study seeks to assess these needs for installers, utility personnel, and local inspectors, investigate the available training alternatives, and make recommendation based upon those findings.

1.1 THREE DIFFERENT AUDIENCES, QUESTIONS, AND ANSWERS

In addressing the fundamental question of the need for training and certification of PV installers in Massachusetts it is necessary to consider at least three different communities that are affected by this issue. Those communities are the distribution companies, the consumers and workers within the Commonwealth (as represented by the General Laws of Massachusetts and the various State Boards that administer them), and the members of the photovoltaic industry. For each of these communities the issue of training and certification for PV installers has different meaning and its resolution has different consequences. In responding to the questions put forward in the original MTC RFP regarding training and certification we feel that a reply that overlooked any one of these sets of concerns would be deficient. As a consequence of the need to address the perspectives of these three different communities the standard of training and the integration and "harmonization" of that training with existing laws, codes, industry practices, and utility company policies, is necessarily more complex.

In a very simplified form, the emphasis of the three communities, as they apply to PV training are:

• Distribution companies:

--Lineman safety as affected by customer sited, grid parallel generation (UL 1741)

--Grid quality due to effects of customer sited generation (IEEE & ANSI standards)

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[1] This report is divided into three major sections. The first is the analysis and recommendations that are based upon the literature search, interview and survey data taken in the course of the study. This is the essence of the study and its structure, starting in subsection 3 below, follows the structure of the original RFP. The second part of this document is the appendix with references and links to citations, and summarized survey data –principally spreadsheet summaries of national program parameters and coded survey results-- with commentary. The pool of data, while extensive, covers wide and varied range of commercial, governmental, academic institutions. It is often very heterogeneous in its characteristics and consequently simple comparisons and correlations are difficult and it is necessary to note the qualifying annotations in the summary statistics. The third section of this report is the archived raw data. This includes the actual surveys, transcripts of interviews and other materials. This will not be included with the deliverable but will be kept by the CIC for future reference.

• Commonwealth of Massachusetts

--Consumer safety (as expressed in minimum safety performance standards of the Massachusetts Electrical Code 527 CMR 12.00 and the Massachusetts Building Code 780 CMR)

--Worker Safety (OSHA regulations)

• Photovoltaic Industry

--PV safety (as expressed in established industry practices)

--PV system quality and performance

The emphasis of these three differing orientations leads to different methods, approaches, solutions and content when considering the need for training and certification for PV installers. We will attempt to include all of the concerns that we believe are pertinent to the situation in Massachusetts.

1.2 METHODOLOGY

Our core research methodologies were:

- Face-to-face interviews and telephone interviews
- Written questionnaires
- Review of government documents, secondary literature, & recent reports

In some cases, for some communities, combinations of these approaches were used, in multiple iterations, to narrow the focus and clarity of the survey instruments. Because the communities differed greatly in size, accessibility and homogeneity different approaches were used to query each population.[2] For the installers in particular, multiple iterations of the survey instrument were developed before the final version was disseminated. The first draft of the survey was created based upon a dialogue among the principal investigators and then through face-to-face or by phone interviews with well-established experts in the community. The surveys required respondents to rank the relative importance of specific aspects deemed most relevant by the experts along two dimensions – requisite knowledge and training needs.

[2] Electrical and building inspects numbered in the hundreds, while the utility personnel number only four. Inspectors could often be accessed through their professional organizations, while the installer community was extremely diverse and had to be reached through mailings, email, on-line surveys and follow-up phone conversations.

1.3 EXPANSION OF SCOPE: LEGAL CONTEXT OF LICENSURE[3]

1.3.1 Massachusetts General Laws (MGL) and the Code of Massachusetts Regulations (CMR) Pertaining to Electricians and Electrical Installations

The investigation of training and certification of PV installers in Massachusetts is set against a backdrop of legal and regulatory structures of the General Laws of Massachusetts (MGL) and the Code of Massachusetts Regulations (CMR). These laws and regulations define the standards and governance for the electrical work in the Commonwealth and for the people who engage in the business of doing electrical installations for hire. The central section of the MGL that we feel has particular relevance to the topic of training and certification of photovoltaic installers in the Commonwealth is the following:

> "**CHAPTER 141.** SUPERVISION OF ELECTRICIANS.
>
> **Chapter 141: Section 1A. Electricians; licensure requirement; exceptions.**
>
> Section 1A. No person, firm or corporation shall enter into, engage in, or work at the business or occupation of installing wires, conduits, apparatus, devices, fixtures, or other appliances for carrying or using electricity for light, heat, power, fire warning or security system purposes, unless such person, firm or corporation shall be licensed by the state examiners of electricians in accordance with this chapter and, with respect to security systems, unless such person, firm or corporation shall also be licensed by the commissioner of public safety in accordance with the provisions of sections fifty-seven to sixty-one, inclusive, of chapter one hundred and forty-seven.
>
> This chapter shall not apply to: a person not engaged in the business described in this section who employs
>
> or contracts for the services of a person, firm or corporation engaged in such business; or to an apprentice employed by a person, firm or corporation licensed in accordance with this chapter; or to an agent, employee or assistant of a person, firm or corporation licensed in accordance with this chapter who does not engage in or perform the actual work described in this section."

While an investigation of the issues surrounding licensure is beyond the scope of this report, and although we have not sought a formal legal opinion on this matter, it appears that the general laws governing electrical work subsume the electrical portions of photovoltaic installation. If this interpretation of MGL 141 is correct then this has a

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[3] The MTC has requested this study to assess that state of the knowledge base for photovoltaic technology in the installer, inspector and distribution company communities. We have identified the relevant communities and individuals and, through a series of interviews and surveys, have collected input from them regarding their understanding of the technology and their role in the installation process.

significant bearing upon the value of a certification conferred by a non-state entity in the Commonwealth. In Rhode Island similar state law has been the basis for insistence by the Department of Labor and Training (the equivalent of our Board of Examiners of Electricians in Massachusetts) that all work on solar photovoltaic systems be performed by licensed electricians and all solar thermal work be done state licensed plumbers. The links to the full text of the relevant Massachusetts laws and regulations are included in Appendix 2.

Of the regional states that possess statewide electrical licensure Massachusetts has reciprocity with Vermont, New Hampshire and Maine. Connecticut and Rhode Island have similar electrical licensure laws but do not have reciprocity with Massachusetts. New York does not have statewide electrical licensure.

1.4 CONCLUSIONS AND RECOMMENDATIONS

• No currently available training and certification program meets the unique needs of photovoltaic installers working in, or the licensure requirements of, the Commonwealth of Massachusetts.

• Surveyed New England PV installers were most concerned that both electricians and the more general installer workforce, be knowledgeable and trained in DC circuitry and specifically article 690 of the National Electrical Code (NEC). For the more general installer workforce there was greater emphasis on knowledge and training about the basics of Photovoltaic systems, basic safety practices, and site assessment as well.

• The MTC should enter into preliminary negotiations with the North American Board of Certified Energy Practitioners (NABCEP) and begin a gradual, phased approach to the adaptation and adoption of their program for Massachusetts PV installers.

• Certification should be encouraged, but not made mandatory or a necessary condition for eligibility for MTC funded projects. Instead NABCEP certification should be listed as *one* of several criteria that will be considered when evaluating grant proposals.

• The preferred approach to providing training and certification for PV installers is to create a regional resource center. A training provider with established programs of training and certification in a related field, such as electrical apprenticeship, is desirable. Furthermore, it is recommended that MTC encourage one or more instructors attain Institute for Sustainable Power (ISP) certified PV Trainer status (possibly subsidizing instructor training) and MTC support the training provider efforts toward attaining ISP accreditation. Additionally, opportunities for cost sharing of training resources should be explored. Overtures should first be made to other states that already have reciprocal electrical license arrangement with Massachusetts (VT, ME, NH).

• The MTC should create an outreach program to electrician licensed in the Commonwealth to familiarize them with photovoltaic technology, the relevant sections of the Massachusetts Electrical Code, the programs of the Solar to Market Initiative, and the network of PV installers that might be in need of their services. The electricians that have attended the outreach sessions would then be a resource to the PV installer community.

• The MTC should create a training outreach program to municipal electrical and building inspectors through their professional associations. It should do this by first identifying and enlisting key "mentors" and leaders within the inspectorate and engaging them in code seminars in photovoltaic technology.   Such a program would leverage the experts within the inspector community who are employed through the informal network of code consultation that local inspectors rely upon for expert advice in unfamiliar situations.

• The development of a specialized renewable energy workforce that is integrated into the mainstream of the construction industry is a long-term process. Training and certification programs that mimic the structure of related building trade (electricians) licensure formats should be favored. The hierarchical format of electrical licenses and sub-licenses should be studied to investigate the possibility of an eventual Solar Installer category (limited certificate issued by the Board of State Examiners of Electricians within the Division of Professional Licensure). Training should include curriculum to familiarize PV installers with the scope of work permitted under Massachusetts General Laws and current conventions for competitive bid contracting for public works projects.

2.0 PV WORKFORCE TRAINING AND CERTIFICATION ANAYSIS

2.1 NATURE OF TRAINING AND CERTIFICATION PROBLEMS, PERCEIVED AND EXPERIENCED

2.1.1 Factors Affecting Training and Certification Problems

Several key disadvantages have been noted for establishing individual certification programs. They include:

The assumption that individual certification guarantees competence in all settings: There are limits to individual competence. Practitioners in most occupations can either work on their own independently or they can work for an employer. If they work for an employer, the working conditions created by that employer can have an impact on their ability to demonstrate competent performance in their occupational field. *Case in point*: in the medical profession, surgeons may have met all requirements for a medical license (medical school, passing the medical exam for the State, internship, residency, and then Board certification). However, they usually ply their trade in a hospital that has also been accredited (according to JCAHO accreditation). If the hospital had not been accredited, surgeons may not be supplied with the essential work environment they need to perform competently (a sterile operating room, nursing support, medical instruments, and so forth). The point is that individual competence has its limits and is constrained by the organizational setting or employer for which the individual works. Employer policies can lead to individual incompetence. *Case in point*: Many auto dealers make it policy to require automobile mechanics to purchase their own tools. That leads to situations in which auto mechanics cannot perform competently, though they know what to do, since they have not been supplied with the tools they need to perform.

Exclusivity and potential job exclusion of underrepresented groups: There is a difference between creating voluntary certification and a mandatory certification. A voluntary certification is undertaken by an individual because he or she wants to possess a desirable credential. A mandatory certification implies that an individual may not get or keep a job because he or she is lacking a certification. In short, a mandatory certification becomes a condition of employment. If that is the case, then government laws, rules and regulations that affect Equal Employment Opportunity apply to the attainment of that employment.

The U.S. government established the *Uniform Guidelines on Employee Selection Procedures* to govern fairness in tests that relate to employee selection. Any test that is a condition of employment must adhere to these standards. An important issue in certification is *disparate impact*, the principle that an otherwise neutral selection measure (such as education, experience, certification, or other requirements such as sex, age, height, or weight, for instance) may constrain employment and exclude historically underrepresented groups such as women and minorities. Great care must be taken to ensure that tests created for a certification adhere to the Uniform Guidelines and that applicants are tracked to ensure that underrepresented groups or protected classes are not deliberately or even accidentally excluded from meeting certification requirements. Additionally, there is need to explore the issue of reasonable accommodation, the principle under the Americans With Disabilities Act that indicates that an employer must identify bona fide occupational requirements and take steps to allow individuals with disabilities to qualify. That includes the testing measures used in implementing a certification program.

Costs: Anecdotal evidence suggests that the management structure needed to establish and maintain a professional certification is costly. Private sector organizations will undertake it when the profits exceed the costs. That can happen when test preparation material is essential, since sales of such material is the most profitable component of a certification program. (Many certification programs themselves are loss leaders) In the case of the PV industry, as for other industries where public policy has large and even determining influence on the market, the costs and viability of a certification program will be dependent and vulnerable to the public policy commitment at least until the industry is of sufficient scale to support the certification program.

2.1.2 Impact of Problems on PV Customers, Industry and SMI Programs

As an emerging and still nascent industry, the PV installation workforce is relatively small, both state wide and nationally. The two certification efforts described below are still in formative stage and can only anticipate the scale of activity that will ensure adequate industry support for the establishment of a securely based and cost effective program. In the case of the PV industry, as expected for an industry where public policy plays a crucial role in determining profitability, these certification programs to varying degrees have secured critical support from federal and state public funding. The public sector commitment must be maintained and/or the growth of the PV industry must be sufficient so that the viability of these programs is sustained. The former may well be required to stimulate the latter. The impacts of a certification program differ depending upon whether it is adequately supported. A high performance certification program will sustain and ensure regular revision of standards to meet updated industry technology and practice and develop and administer evaluations of competency adequate to ensure that certified installers are in fact delivering a higher level of PV installation safety and performance. Otherwise customers will bear higher costs of certified installer services without the expected performance gains. The industry will bear the costs (certification application, renewal fees and professional development required to maintain competency in accord with evolving industry standards) and will not gain in reputation and Massachusetts SMI activity will directly or indirectly be bearing certification developmental costs without commensurate advantages.

Assuming the certification program is well established and meets the expected goals, the impacts of the problems identified in the preceding section suggest customers will be more informed about the competency of individual certified installers but they will not necessarily have adequate information about the contracting firm. However, assuming a voluntary certification program the consumer will still have the choice of installer and contracting firm. The industry will be vulnerable to concerns and potential legal liability as regards policies toward historically underrepresented groups and reasonable accommodation when applicable. Awareness of these concerns may facilitate early adoption of policies that assure procedural fairness in employee and contractor selection. The industry will also bear the higher costs of training for certification and related training indirectly through higher wage costs and possibly directly if they support these costs for their employees preparing for and taking certification examinations. As described below, the SMI program may find a certification program can ease its burden in the selection among applicants but other aspects of contracting firms will still be required in part to ensure certified installers are adequately supported in attaining performance standards of which they are capable. Additionally, the SMI programs should include in its selection criterion for participating firms, assurances that they are abiding by guidelines for fairness in employee selection. Finally the costs per installation may be raised due to higher wages paid certified installers, and SMI must expect lower selection costs and higher performance per installation as compensating factors.

2.2 BENEFITS OF TRAINING AND CERTIFICATION, PERCEIVED AND EXPERIENCED

2.2.1 Factors Affecting Benefits of Training and Certification

Several key advantages have been noted for establishing individual certification programs. They include:

Enhancement of the profession and increased visibility: An individual certification program increases the visibility of an occupational specialty or profession and increases the confidence of consumers or customers of that occupation that practitioners adhere to the highest standards of competence and ethics.

Recognition and increased earning potential: Individuals who achieve the certification can be recognized for their accomplishment. In addition, attainment of a certification has been shown to improve the earning power of certified practitioners.

Standardization and quality assurance: Certification required background research to clarify the work requirements necessary for successful practice. Common approaches to do that include task analysis, competency identification, and/or the outlining of the body of knowledge unique to the discipline, field or occupation. By clarifying the work requirements for successful practice, the field begins to become more standardized in its common business practices and approaches. That, in turn, can lead to clear measures of quality.

Potential for improved safety: In the process of investigating the work requirements and activities essential for competent practice of a discipline, investigators can pinpoint common areas giving rise to safety concerns and accidents. They can also ensure that such issues are included in a certification process to ensure that individuals who are certified have been trained on safe work methods and are aware of safe work practices.

Flexibility of self-regulation: The occurrence of serious injury, fire, pronounced and widespread under performance of installations, or other dramatic and widely noted mishaps, would likely bring a strong regulatory standard and public oversight, as well as retard industry growth. A goal of establishing a workforce of certified installers would be to prevent such initiating events, provide a rapid system of corrective measures and retain flexibility in ongoing review of standards and competency expectations.

2.2.2 Impact of Benefits on PV Customers, Industry and SMI Programs

Given the importance of SMI approval of applicants for current customer base and industry prospects in Massachusetts, SMI is in effect a joint customer as well as an industry partner through its role as the developer of programs to promote solar alternatives. The following benefits will be shared, some directly and others indirectly, among customers, industry and SMI.

Certified practitioners, as described in the preceding section, will gain widespread recognition of competence in installing PV systems. They will gain in earning power and mobility to a greater extent according to how widely accepted and preferred the certification credential is regarded, especially within the northeast marketplace. Similarly a more widely accepted certification means that consumers and the SMI in Massachusetts may have a wider pool of qualified installers competing for selection from nearby states as well. Beyond the additional professional development costs, the extent of higher wages will depend upon the growth of market demand in relation to the number of installers qualifying for certification.

As certification is voluntary, consumers and the SMI will have choice in selection in considering relative cost and expected performance of certified and other installers. However, certification creates an easier method for evaluating competence of a prospective PV installer, decreasing costs associated with hiring or selection, and providing greater assurance a competent installer is hired. Certification also demonstrates a commitment to responsible PV installation. The expected benefits of PV installation by certified installers also include installation cost efficiency, fewer accidents and errors as well as improved system performance and reliability. These benefits also lead to reduced risk and liability exposure, and therefore potentially improved access to capital and insurance. Certification credentials and standards of performance can assist in establishing a due diligence legal defense if necessary.

The PV industry and SMI goals are advanced through marketing benefits and improved public credibility by advancing greater awareness of a certified workforce. The industry will also gain the benefits of potential partnerships between the industry and training/education providers. Economies of training are likely with the prospect of standardization of basic knowledge to be taught, an infrastructure to provide more rapid updating of new standards, and greater consistency of curriculum.

SMI and the Commonwealth would benefit from the attainment of better PV performance standards, a stronger ethical base among the practitioner community, the contribution to the national and international recognition for leadership in PV industry practice, and harmonization of Massachusetts with other jurisdictions - regionally, nationally and internationally.

3.0 PV SYSTEM INSTALLER TRAINING AND CERTIFICATION

3.1 BACKGROUND INFORMATION ON PV INSTALLER TRAINING AND CERTIFICATION

3.1.1 Case Studies for Training and Certification in Other Industries

This section briefly reviews and highlights limited aspects of the recent development and expansion of certification programs in several electrical related installation occupations, primarily telecommunications, in order to provide insight into the prospect of an emerging certification program for PV installers. The case comparison with the telecommunications installer workforce is instructive for the differences as well as the parallels to the PV installer workforce. The deregulation of the telecommunications industry and the break up of ATT, transformed the structure of competition and created new opportunities for independent design and installation occupations. This process with its own industry variation has been occurring since the deregulation of the electricity supply industry and the emerging distributed generation of electrical power, of which the grid tied PV sector is a segment. The central difference is that, for the most part, the occupations in telecommunications related fields described below, are engaged in the design and installation of low wattage (commonly referred to as power limited) cabling.

The U.S. Bureau of Labor Statistics recognizes the following occupations as "involving similar duties, skills, interests, education, and training"[4]:

[4] U.S. Department of Labor, Bureau of Labor Statistics, Occupational Outlook Handbook, "Electrical and Electronics Installers and Repairers" http://www.bls.gov/oco/ocos184.htm and, "Radio and Telecommunications Equipment Installers and Repairers" http://www.bls.gov/oco/ocos188.htm

- electrical and electronics installers and repairers;
- radio and telecommunications equipment installers and repairers;
- broadcast and sound technicians and radio operators;
- computer, automated teller, and office machine repairers;
- electronic home entertainment equipment installers and repairers.

In 1998, U.S. and Canadian based professional and trade associations employing large numbers of workers in these sectors along with associations of "Security and fire alarm systems installers" joined together to form the Consortium for Electronic Systems Technician Training (CESTT). When formed this Consortium included 9,000 firms with 180,000 "electronic system technicians" (ESTs) with an average employment of 20 ESTs. An EST is defined as an individual whose primary occupation is the "design and/or integration, installation and field maintenance/service of:

- cabling infrastructure and products that transport voice, video, audio and data signals in a commercial or residential premises;
- products that capture and display or otherwise annunciate signals; products that control signals;
- and products that use signals to control mechanical and electrical apparatus. [5]

The Consortium's initial goals were to identify and clarify the specific technical competencies sought in technical personnel and to consider options for addressing a chronic shortage of entry-level technical employees. The individuals and workers in the companies that are members of these organizations are primarily (but not exclusively) engaged in the installation, operation and repair of power limited electrical and electronic systems. Several of these sectors have seen rapid employment growth. Even as technological changes may shift employment growth from installers to repairers in main sub specialties, the expectation is for rising employment opportunities among security and fire alarm installers and telecommunications networks. The latter group will be supporting the growth of central office and private branch exchange (PBX) networks, expanded multimedia and other telecommunications services particularly those tied to the increasing role of the Internet.

The occupations and trade associations in this mix of related sectors have varied histories of development of certification programs. Due to the safety concerns related to reliability of operation the security and alarm installers are often licensed, as they are in Massachusetts as a sub category of electrical licensure. The very dramatic changes in the telecommunications industry following upon deregulation prompted a movement toward establishing certification that was well supported by the profession at the system design level first (late 1980s)

[5] The Consortium for Electronic Systems Technician Training, "The Job Market: Employment Survey - Electronics Systems Technician" http://www.hightechjobs.org/job_market.html

and more recently for installers (1996). Individuals certified in the former category, Registered Communications Distribution Designer (RCDD) have demonstrated expertise in the design, implementation, and integration of telecommunications and data communications transport systems and related infrastructure. Additional sub certification categories have been established for specialty design fields. The second, category of installers grades 1 and 2 and technicians work with differing degrees of proficiency and troubleshooting in telecommunications/low- voltage cabling distribution.

These certification and training programs in the field of telecommunications were pioneered by the Building Industry Consulting Services International (BICSI) an organization whose membership grew from 132 in 1980, to 1,482 in 1990, to about 20,000 in 2000. (www.bicsi.org) BICSI members are providers or suppliers in the fields of telecommunications infrastructure design, data distribution design, outside plant design, low voltage cabling installation and residential cabling installation. At an early stage in program development, BICSI followed legal advice to refer to their qualification program as "registration" (as is the practice for registered electrical engineers) to avoid potential legal liability associated with the "certification" of competency. Apparently however, it is common practice in the industry to refer to "registered" individuals as "certified". The BICSI certification program is currently conducted at a very formal level in accord with the general process criteria described in section 3.11.2 below. This process evolved from early informal meetings in the mid 1970s until the body of knowledge was formally codified in 1985 as the basis for the first training to meet certification standards. With this organizational experience in hand the certification standards for installers and technicians conducted at a formal level beginning in 1993 took only 3 years to develop training materials and deliver courses to prepare for certification examinations. Since 1996 over 17,000 individuals have been enrolled in training courses and over 5000 are currently "registered" telecommunications installers or technicians. There is an Installer level 1 that is equivalent to an apprentice; Installer level 2 requires two years of experience at level 1 as well as a higher level examination; and Technician requires as least 5 years experience, Level 2 training, and an examination. Preparation and documentation to take the higher level examinations is facilitated by a "book in the back pocket" with specified tasks and a supervisor's sign off that the work was performed with proficiency. [6]

The strengths of these programs has been demonstrated by the extent of industry support. By the early 1990s the "general contractors (were) insisting that the communications wiring be done by registered communications distribution designers (RCDD)." (Stoffels, 1993) Currently the efforts that have supported the certification of telecommunications installers and technicians have also prompted a contested legislative process in Massachusetts, still unresolved, to revise the licensure of electricians more generally. Massachusetts Senate bill

[6] (www.bicsi.org; Building BICSI History and Mission Statement, http://www.bicsi.org/Content/Files/PDF/history.pdf ; personal communication)

2375 attempted to specify separate telecommunications licenses for work distinguished according to application by telephony, data, voice, audio, video, and distinguished from current electrician licensing. This bill was defeated[7]and current proposals under consideration not only define new and broad telecommunications sub licensure categories for electricians, but provide additional limited L licensures for a wide range of work. The growth in the occupations and the certification efforts described above, including the leading effort in telecommunications, is in effect aiming to extend the nested tiers of electricians licenses. Developers of the certification and training for telecommunications installers perceive the Massachusetts initiatives as the frontlines of an industry seeking relief from what is perceived as an excessive standard of licensure for practitioners, particularly those working with power limited systems.

3.1.2 Rationale for Training and Certifying PV Installers

The rationale for training and certification of PV Installers is, in part, related to the key advantages of certification generally.

First, the process of establishing a certification and training program will tend to make the requirements for entry into the field clear and uniform. Individuals may have to meet specific qualification requirements to be eligible to achieve certification, such as meet requirements for a minimum amount of education, experience, and other qualifications as a group of experts in the field establish as minimally acceptable.

Second, establishing a certification and training program will tend to attract the attention of other people who are interested—and perhaps some who are not. It will, in short, attract attention to the photovoltaic field generally, potentially sparking thoughts about it among those who might be interested. It may also stimulate educational providers to become involved, and thereby increase the professionalism with which a certification and training program is organized and managed.

Third, establishing a certification and training program may limit the occupational entry to the field of photovoltaic installation to a smaller group of providers. That, in turn, can place a premium on the services of those who achieve the certification. They can thus charge more for their services, which will be in demand.

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[7] (Massachusetts Systems Contractors Association, "Background Info on Licensing" http://www.massalarm.com/Background%20info%20on%20Licensing.htm ; Massachusetts Systems Contractors Association, "Sounding the Alarm on the Telecommunications Licensing Bill S. 2375" http://www.massalarm.com/Sounding%20the%20Alarm%20on%20S%202375.htm ; personal communications)

Fourth, establishing a certification and training program will lead to standardization and to quality assurance. As a certification process is established, the certifying body will need to ensure that a complete job and task analysis has been conducted to clarify exactly what photovoltaic installers do, how they do it, what results they get from it, and what are common measures for assessing the quality of what they do. This process will, in turn, lead to the standardizing of approaches, since everyone will be trained in keeping with a standardized approach. As they are trained, they will learn a way to do it that complies with most efficient, effective, and safe approaches. Additionally, that will increase the quality of what they do and make it easier to judge the quality of service provided across many practitioners who are carrying out this work. It should be noted that a recent innovation in the field of occupational analysis has been to focus attention on the characteristics and approaches that distinguish best-in-class performers (called "exemplary") from the merely average (called "fully successful") performers. Rather than a substitute for job or task analysis, this approach—called *competency modeling*—adds a new, powerful dimension to the way that occupational analysis is conducted and can affect how people are selected and trained to do work. It can also provide useful information for establishing occupational entry requirements based on investigations of the personal characteristics that may distinguish exemplary from fully-successful performers. [8]

Fifth and finally, establishing a certification and training program will lead to an opportunity to improve safety. As a certification process is established, the certifying body can investigate the most common accidents in the field and why they happen. The results of that investigation can be built into the training so that practitioners have been trained, in advance, on the most likely causes of safety problems and how to avoid them.

3.1.3 Related Training and Certification in Other States/Nationally

We were able to identify about 46 course offerings by established organizations ranging from state agencies such as NYSERDA, to private companies such as Endecon Engineering and Solar Energy International, to state and federally funded institutes such as the Florida Solar Energy Center (FSEC) and the Southwest Technology Development Institute (SWTDI). We found an additional six courses or full degree programs at five colleges and universities (notably University of Massachusetts, Lowell offers a masters degree in Energy Engineering, Solar Concentration). In addition we have found many small-scale single or partial-day workshops and courses for PV for beginners. These smaller offerings tend to occur at energy fairs and related venues across the country. Most of the training programs we identified, with the exception of the college degree programs, do not offer any true certification (some have in the past but appear to have backed away from the practice). Instead

[8] For more information on the theory of this approach, see *Competence at work* by Spencer & Spencer and *Competency-based performance improvement* by David Dubois; and, for a book that shows how to do this step-by-step, see Dubois, D., & Rothwell, W. (2000). *The competency toolkit*. 2 vols. Amherst, MA: HRD Press.

they may offer a, "certificate of completion." Many of the more established training programs travel across the country. They are a potential resource to Massachusetts.[9]

Although most of the programs we have encountered do not offer formal certification, several states have made various levels of commitment to, or expressed eventual willingness to adopt, the NABCEP training and certification program. In our most recent contact with Jane Weisman of the NABCEP board of directors and through telephone contacts with a variety of state agencies, we have found that New York, New Jersey, California, Ohio, Rhode Island, Arizona and Texas have either made commitments to NABCEP or are considering the adoption of the program once it has been launched nationally. NYSERDA is a strong supporter of the NABCEP program and intends to make it a cornerstone of their installer training efforts. NYSERDA provided an initial grant of $75,000 about a year ago to NABCEP. NYSERDA has now committed $200,000 to NABCEP, which they are about to finalize contractually. As part of this arrangement NABCEP will locate its headquarters in Malta, NY, at the Saratoga Technology Energy Park (STEP) next to the Building Performance Institute (BPI).[10] NYSERDA's professed objective for their training program is to meet their needs and vet their workforce using the NABCEP program. In California the California Energy Commission (CEC) has stated that it "intends to require that PV systems installation contractors be certified" under NABCEP standards.[11] (It is worth noting that this proposed requirement by the CEC for NABCEP certification for eligibility for program funding is opposed by several of the people within the NABCEP organization with whom we have spoken. It is the NABCEP stated policy that participation be voluntary.)[12]

Several states have taken the approach of establishing a limited or "sub-license" in the electrical category or an entirely separate category of solar license. In Florida there is a Solar Contractor license issued by the Construction Industry Licensing Board, under the Department of Business and Professional Regulation.[13] In Oregon there is a limited renewable energy contractor license and a limited renewable energy technician license issued by the Department of Consumer and Business Services and administered by the Electrical and Elevator Board.[14] And in California the Contractors State License Board issues a C-46 Solar Contractor license. There is

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[9] Details of these programs are covered in greater detail in section 3.13.
[10] Interview with Adele Ferranti, Sr. Project Manager, Energy Resources, NYSERDA 3/24/03
[11] California Energy Commission, Emerging Renewable Program: Committee Draft Book, 2/2003
[12] Interview with Peter Lowenthal, VP of NABCEP Board, 2/21/03
[13] Florida Department of Business and Professional Regulation
[14] Christopher Diamond, Oregon State Office of Energy, 11/02

currently a proposal before the Connecticut legislature to change the legal definition of "Solar Work" in the general statutes governing contractor licensing to include solar electric systems.[15]

For a full summary of training and certification programs, by state and institution, refer to Appendix 3: PV Training and Certification Initiatives. Links to information on states with solar contractor licenses and electrical sub-license are included in Appendix 3.

3.1.4 Current Installer Pool in New England

We estimate that the current pool of PV installers in New England is approximately 46. This does not include the workforce available for large-scale construction, public works, and some new custom home construction, whose labor requirements would be met by either union or non-union electrical contracting firms. Our primary tool for identifying the pool of PV installers for our study was the NESEA Sustainable Yellow Pages. We also compared this list with the names of the award recipients for the MTC cluster program. The list includes large and small contractors, consulting engineers and architects, PV wholesalers and distributors (these companies often offer design and installation services), one utility (manages some of its own PV installation projects) and one electrician. In total we identified 46 installer, 20 manufacturers, and 31 dealer/distributors. Several companies are listed in more than one category. Of the pool of 46 companies or individuals that offer various installation related services in Massachusetts and New England, 25 companies responded to a survey. In additional, nine participants provided us with detailed commentary, either through telephone or in-person interviews or through written, letter-format responses.

In practice, under prevailing wage laws, most publicly funded electrical work will be preformed by union contractors. Boston Local 103 of the IBEW has embarked upon an aggressive PV training program. They have produced a training DVD that is expected to be ready for distribution in 2003. The business agent for Local 103, Mr. Martin Aikens, has indicated a great willingness to share their experience with other locals (the training DVD is itself a deliverable for an MTC program and would presumably be available unrestricted distribution). Local 103 has recently completed two PV installations, including one on their Dorchester training facility, and is incorporating PV training in the list of courses available to their membership. On the national level the IBEW is extremely active in the NABCEP program occupying a seat on the board of directors. [16]

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[15] For further details contact Richard Hurlburt, Connecticut Division of Occupational Licensing, 860-713-6154. See Appendix 3: PV Training and Certification Initiatives, General Assembly Raised Bill No. 1114 (An Act Concerning Solar Work)

[16] For a full summary of training and certification programs, by state and institution, refer to Appendix 4: NEPVIndustryContact.xls.

3.2 ASSUMPTIONS REGARDING TRAINING AND CERTIFICATION

3.2.1 Estimated Growth Potential for PV Installations in New England

Unlike traditional two-factor models of simple supply and demand, the market for grid-connected, residential PV is driven by the interactions of three players. On the demand side are consumers (end-users) and investors using public funds to invest in technology with perceived positive economic externalities. The interaction of these consumers and investors yields the demand estimates for PV installations and the derived demand for installers. On the supply side, constrained mainly by the current state of technology and scale of production, are PV module manufacturers and installers.

The PV suppliers represent a technology with a promising future but a limited present without public policy support or changes in current policies to impose the internalization of full cost on nonrenewable energy sources. Providing power at four to five times the cost of utility generated electricity[17], the PV industry can only expand in limited specialty markets without policies promoting PV market growth. This presentation identifies further public policy subsidies in a variety of forms from existing and proposed state and federal programs that would make the kWh cost of PV generated electricity less than current retail rates. The following analysis ignores these other forms of PV subsidy that are in fact (or potentially) significant factors influencing consumer choice.

A well-known business model usefully applied to the demand potential for PV installations, elaborates three generic strategies.[18] These strategies are 1) cost leadership and 2) product differentiation supporting price premiums and 3) very narrow niche markets. The ideal growth of the PV industry would follow these strategies in reverse order. First, market to narrow niches such as remote off-grid sites. Second, market to on-grid consumers who will pay a premium to consume high cost electricity produced in an environmentally friendly manner. Third, when the cost of PV-generated electricity is equal to or less than the conventional utility-based power grid, the PV industry will be producing a commodity. While the term "commoditization" has a negative connotation for most markets and products, in this case the commoditization of PV-generated electricity is a very desirable outcome.

The key to moving from focused niche markets to markets where consumers will pay a premium for a special, or differentiated, product, in this case PV power, is to understand the exact price premium that results in a viable market for special, "green" power. Data from each case draws out the level of price premium that the market

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[17] Andrew Greene and Lisa Frantzis, "Rays that Pays: Grid-Connected PV Reduces Electricity Cost by Tapping Old and New Drivers," Navigant Consulting, Inc., December 2002.

[18]Michael Porter, *Competitive Strategy* : techniques for analyzing industries and competitors / Michael E. Porter. New York : Free Press, c1980

requires. The price premium is closely related to three concepts in philanthropy[19] that reflect public policy priorities as well. First, cases where gifts bring no benefit to the donor are called charity or eleemosynary donations. This does not apply to the PV marketplace. Second are cases where donations or investments create pure public goods such as infrastructure improvement. This also fails to apply to the PV sector so far as the major expenditures are to subsidize individual installations. Third, certain gifts or investments create positive externalities, where the benefits spill over into society but cannot be fully recovered or captured by the party providing the benefits. This describes the motivation of groups like MTC who seek to invest part of the RETF in a manner that creates positive externalities; i.e. less peak demand and fewer brownouts, less acid rain, reduced need for transmission lines and other investments in power distribution, and reduction of risk from fission-based power production, to name a few. Many lead consumers, residential and commercial, may share some of these motivations.

This approach provides a framework for interpreting the case studies of PV subsidy programs. The price premium paid for green power ought to be aligned with the desired level of positive externalities created by social investment agencies. (For example, one state seeks "10,000 rooftops" in order to achieve a desired level of positive externalities, but is unwilling to invest in 50% to 75% subsidies needed to make PV power competitive -- not in a commodity market or niche market, but in a mainstream differentiated product market.)

This report will provide estimates based on recent industry experience that identify bands of social investment that can be matched with consumer demand and thereby produce an estimate of market size and labor needs.

The experience of the Long Island Power Authority (LIPA) between 1999 and the present time indicates that a subsidy of approximately 30% is not sufficiently attractive to grid-connected consumers. However, the LIPA experience also indicates that subsidies significantly higher than 60% are probably a little too attractive. As a result, LIPA is testing a net subsidy package somewhat higher than 50%.

Table 1. LIPA Rebates and Installations: 1999 to Present

$3/W Subsidy	$6/W Subsidy	$5/W Subsidy
1999-2001	12/5/2001-7/15/2002	8/1/2002-Present
16 systems installed/37kW	**202 systems installed**	Forecast of 130 systems*

*500kW “block” of funding

[19] *Three Categories of Philanthropy, Fund Raising and Public Relations: a Critical Analysis*, Kathleen S Kelly 1991, Hillsdale, N.J. : L. Erlbaum Associates, ISBN: 0805809430

Florida now offers a $4/W rebate; considering lower labor costs, better insulation, ratio of floor area to roof area, this is probably in the 50% range. The $4/W rate represents an increase from the prior $2/W rebate offered a year earlier. During the course of the program, 6 rebates were taken at the $2/W rate, while 19 rebates were taken at the $4/W rate.

New Jersey offers a $5/W subsidy for most residential-sized systems. The state's experience with $3/W subsidies led to fewer than anticipated applications and the PV industry lobbied for the higher rate.

In California the term used for participating in the buy down program is "to reserve" funding[20]. Before instituting a buy down program in 1998, grid connected PV systems were installed at the rate of 1 system per month. With a $3 per kW subsidy, the rate of installations increased to 30 systems per month. After January 2001, however, with a $4.5/W subsidy (up to 50% of system cost), system reservations increased to nearly 300 per month. The state's energy crisis played a major role, indicating that increasing public anxiety combined with threshold levels of subsidy results in significant increases in demand.

For small, residential PV installations, 6 states currently offer buy down subsidies. The level of subsidy indicates the experienced threshold level in this market segment. The cost assumption is $10,000 per installed kW.

Table 2. Subsidy Range of Selected Rebate Programs

Subsidy	State	Maximum Rebate per system, based on system cost
$6.00/W	IL	60%
$5.00/W	NJ	60%
$5.00/W	NY (LIPA)	
$5.00/W	RI	50%
$4.50/W	CA	50%
$4.00/W, in two steps	PA	80%
$4.00-$5.00/W, in two steps	NY	50%-70%

Experience indicates a range of $3/W to $6/W, with a threshold between $4.50/W to $5.00/W, or about half the system cost. To date the lower levels of subsidy have failed to generate significant interest in the programs.

[20] http://eetd.lbl.gov/ea/EMS/cases/BuyDowns

However, the states are attempting to fine-tune their programs to arrive at the lowest subsidy threshold. Applying these observations to the situation in Massachusetts we can estimate the number of kilowatts of capacity that is likely to result from the level of funding available through the current PV installation grants. Presently there are two grant programs that are scheduled for distribution over the next year and a half. They are the Cluster PV Installation Grant and the Open PV Installation Grant, with a combined dollar value of approximately $4,300,000 and a funding level of up to $5/Watt. Assuming that all of the matching grant dollars will be allocated and that the average system cost will be approximately $10/W, this level of grant will result in a combined public/private investment in installed PV of approximately $8,600,000 during the grant period. This, in turn, will result in approximately 860 kW of PV capacity installed.

3.2.2 Projected Demand for PV Installers

We believe, based upon our interviews with PV installer community, that any projected increase or decrease in the workforce would follow the funding trends in the grid-tied photovoltaic market closely. We have also made the assumption that the market for off-grid PV is largely independent from that of grid-tied photovoltaic installations. Aside from catastrophic external influences on the off-grid market, such as the Y2K scare or other threats, real or perceived, we assume that market to be relatively stable. Thus future fluctuations in the PV workforce will be a consequence of the growth or decline in the rate of grid-tied photovoltaic installations, which in turn is directly dependant upon the size of block grants available over a given time period and the subsidy level expressed as a percentage of system cost.

We have estimated of the number of installer hours required per kilowatt of PV installed through conversations with three local installer/integrators. The range for the installation hours per kilowatt installed varies between a low of 25 hours and a high of 60. This range, used in conjunction with a knowledge of the current funding levels for PV installations, provides a tool for gauging the demand for PV installers. The question of how demand for additional labor hours translates into the number of PV installers is a more difficult one to answer. From our interview with PV installers we know that the companies we surveyed offer a diversity of services. Depending upon the firm their business may include off-grid or solar thermal installations, data acquisition and analysis, insulation and energy management services, or even general construction. Many of the companies that responded to our survey indicated that they used full time, part time, and temporary employees, as well as subcontractors. If the demand for PV installations increased dramatically it is unclear what methods these companies would use to satisfy that demand. For Massachusetts the demand for installers derived from the current SMI programs, expressed in installer hours, would be from 21,500 to 51,600 over the period of the grants.[21] The simple assumption is that some initial increase in demand of PV installations would largely be satisfied by currently underutilized PV installation capacity. If PV installations increase beyond current capacity derived demand for installers can be expected to increase proportionally. Given the small size of the current industry, the scaling up of market demand stimulated by SMI, if sustained, is likely to have a relatively large impact on the number of PV installers over time. At the limit, and in the immediate short run, a relatively large expansion of capacity in a small industry, say 50% of the currently identified 46 installers in New England, would require the entry of only 23 additional firms of comparable average size. However, the current installer pool (as reflected in the survey responses) had an average of five full-time and two part time employees. Therefore a scale of expansion of 50% would require an expanded installer workforce of as many as approximately 160 individuals, although it is unclear how many would seek or receive training beyond on-the-job training. The training requirements for new workers is distinct and in addition to the training upgrading required for the existing workforce. Sustained growth would of course change the base installer workforce and smaller rates of growth would then require larger increases in the number of installers.

3.3 TRAINING OPTIONS[22]

At present there are no widely accepted pedagogical standards for content or delivery for training and education in the photovoltaic industry. Our survey of training options offered across the United States yielded an array of programs that varied in content, format, venue, cost, duration, and provider. Offerings are presented on municipal/county, utility service territory, state, interstate/regional and national levels. They are offered by private entities such as PV installers, product vendors, designers and engineering firms such as Solar Energy International based in Colorado or Endecon Engineering from California. Programs are offered by quasi-government institutions such as the Southwest Technology Development Institute (SWTDI) or Florida Solar Energy Center (FSEC). General and product-specific training is also available from manufacturers such as Xantrex (an inverter manufacturer) and Shell/Siemens (a module manufacturer).

A small number of colleges and universities have created programs with structured multi-course curriculums that result in a degree. Most of these result in an associate degree that prepares the student for a career as a solar or renewable energy technician. In our region the University of Massachusetts, Lowell, offers a master's degree in Energy Engineering, Solar Concentration. These programs are listed in more detail in Appendix 3: PV Training and Certification Initiatives.

[21] For details see Appendix 4: New England PV Workforce.

Providers often offer their services across the country. These offerings ranged from brief one-day workshops to structured week long seminars. The International Brotherhood of Electrical Workers (IBEW) is taking steps to incorporate PV training into their apprentice program and the metro Boston Local 103 has produced a training DVD on photovoltaic installation practices and procedures. We contacted two training organization for non-union construction trade groups, the Home Builders Institute (HBI) and the National Center for Construction Education and Research (NCCER), and inquired about their effort in training in renewable energy building technologies. The HBI at one time had a solar training program in their San Diego office however it has been discontinued and changed to plumbing and electrical courses. The HBI program is administered under a contract with the Department of Labor through its Job Corps program and is based on "employer needs." As such these organizations would need to see an immediate workforce/market demand before they would invest in a training program.

While they do not provide any direct training programs the National Renewable Energy Laboratory (NREL) and Sandia National Laboratory have long supported research into photovoltaic technology and PV safe practices. Indirectly their support of SWTDI at New Mexico State University and FSEC at the University of Central Florida provide much of the core expertise for evolving PV installation best practices.

Two organizations are attempting to establish training and certification standards in the PV industry. Those organizations are the North American Board of Certified Energy Practitioners (NABCEP) and the Great Lakes Renewable Energy Association (GLREA). The first of these has taken a more formal approach, including affiliation with an accrediting institution, the Institute for Sustainable Power (ISP). Both of these programs will be reviewed in detail later in this report.

3.3.1 Activities Necessary to Meet Installer Requirements

The question of what activities are needed to meet the training requirements of PV installers begs the question, "from whose perspective?" For each of the three stakeholder communities described in the opening section of this report the answers are slightly different. For the distribution company perspective the answer is the simplest. In the majority of the residential cases simply complying with the utility interconnection requirement by using a UL listed inverter and providing a lockable, visible blade disconnects, where specified, will suffice. For the distribution company the only requirement is that the installer know and follow the companies interconnection standards. This process promises to become even easier as statewide interconnection standards come into being.

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[22] A review of certification *standards* defined by different certification efforts currently in progress will bare upon training options discussed in this section. In keeping with the organization of the RFI a discussion of

From the perspective of the federal, state and local government, in particular as represented by the inspector community, OSHA safety standards, the Massachusetts Electrical Code (527 CMR), the Massachusetts Building Code (780 CMR) and consumer protection laws are the requisite sources of knowledge needed to meet training requirements. Proficiency in and compliance with these standards –for any contractor, in any construction discipline-- is sufficient to meet the standards and concerns of these communities.

For the photovoltaic industry, and the installer community in particular, the concerns of the first two communities are relevant, however not unique to PV. In addition to the aforementioned training there exists, for PV, a need for training aimed at insuring system quality and performance. Unlike the minimum safety standards held in the Massachusetts Electrical Code and the Massachusetts Building Code, this level of consumer protection is economic and not life safety. This is not to say that there are not aspects of PV installations that require careful training to assure the health and safety of the consumer. There are many. However these topics are fully addressed in and are governed by the standards and approved practices in the 527 CMR and 780 CMR23. The type of training that is unique to the solar industry and extends beyond the normal craft of building trades concerns considerations of system design and execution for performance. The following is a partial list of training needs which are unique to photovoltaic installers:

- Training site assessment as it pertains to system performance (assessing the effects of shading obstructions, tilt and azimuth angles, etc.)
- Training in photovoltaic cell and module characteristics as they apply to the design and performance of integrated systems
- Training in calculating system characteristics, such as wire sizes, to minimize power losses and maximize energy production
- Training in applicable wiring methods and technologies
- Training in mounting techniques and technologies
- Training in PV system maintenance, diagnostic and troubleshooting techniques
- Training in customer education practices

Certification Options will follow in Section 3.14.

[23] As a practical matter, because most of the articles from 527 CMR and 780 CMR that pertain to PV installations find little or no relevance in other building practices, any training of PV installers should, of necessity, deliver the relevant sections of these codes as part of the training. In Massachusetts the governance of this work (training requirements, permitting, licensing, testing, insurance requirements, applicable standards, etc.) is already defined as the work that may only be done by people or companies that are licensed by the State Board of Electrical Examiners.

As noted earlier, portions of 527 CMR and 780 CMR that are specific to photovoltaic installations are little studied or used in the main stream of the construction industry in Massachusetts, and consequently should be made a part of any complete PV training curriculum.

One important source for learning and assessing the perceived areas of requisite knowledge and training needs for New England was a survey of forty-six installers identified through NESEA. For the installers in particular, multiple iterations of the survey instrument were developed before the final version was disseminated. The first draft of the survey was created based upon a dialogue among the principal investigators and then through face-to-face or telephone interviews with well-established experts in the community. The survey was first tested by review of the interviewed experts. Since the installer community was extremely diverse several avenues of contact were utilized including mailings, email, on-line surveys and follow-up phone conversations. (The survey and a statistical summary of results are included in Appendix 5.)

The firms were not asked but it was presumed that all of the firms were engaged in other activities in addition to the installation of PV systems. Twenty-five firms completed surveys and reported an average of 9.5 years experience and only 5 with four or fewer years in the industry. Excluding one very large firm, the average scale of the firms was small with an average of 5 full time and 2 part time workers. Twenty-one of the firms reported on the number of PV systems installed.. These firms had installed a total of 644 systems (including national and international firms with a New England presence), an average of 26 grid tied systems, with the largest 7 responsible for 88% of the installations. This group of firms also had installed 544 off-grid systems, with the largest four responsible for 83% of these installations.

Primarily, the survey asked respondents to rank the relative importance of sixty-three specific aspects deemed most relevant by the experts along two dimensions – requisite knowledge and training needs. The installer survey results identify a general high level of importance for the identified areas of requisite knowledge and need for training for safety, PV system quality in performance, customer education and ethical business practices. These general results were a validation of the areas of knowledge identified by experts in the construction of the survey questions. There were a few areas of notable greater emphasis in respondents ranking of the importance of certain knowledge areas and training needs. As regards both the importance of knowledge required for success and the need for training in the area of safety, installers were most concerned that both electricians and the more general installer workforce, be knowledgeable and trained in DC circuitry and specifically article 690 of the NEC. For the more general installer workforce there was greater emphasis on knowledge and training about the basics of Photovoltaic systems, basic safety practices, and site assessment. There was a significant lower level of concern with training in regard to cranes and motorized lifts as well as knowledge of other renewable energy sources.

3.3.2 Possible Implementations of Training Activities

Three common approaches to providing training in an emerging technology are to draw upon resources from academia, from the engineering and research community, and from experienced practitioners within the marketplace that are implementing the technology in their daily business. All of these have their strengths and weaknesses when considered in the context of the needs of the installer community. Within the options that lend themselves to the training needs of PV installers are:

- Establishing a mobile resource, such as a PV-equipped trailer, and associated training staff
- Establishing regional resources centers at vocational technical high schools or junior colleges
- Establishing regional resources based at state universities
- Contracting with outside providers such as FSEC or SWTDI for periodic course offerings
- Providing funding for Massachusetts installers to attend courses out of state

All of these options could use either the GLREA or NABCEP programs to provide administration and credentials.

3.3.3 Pros and Cons of Training Surplus Installers

The assumption in this section is that the training of installers increases at a pace significantly greater than the market growth of demand for PV installations. The central impacts of training a surplus of PV installers can be separated into short term and long term effects. In the short run a relative surplus of installers will provide more choice by consumers in hiring contractors and SMI in selecting among program applicants in identifying expected and preferred tradeoff of performance relative to cost. The surplus supply of installers is expected to result in a lowered cost relative to the quality of installation as installers seek to excel in both dimensions to maintain income and business solvency. Otherwise intensified competition diminishes market share and the likelihood of firm survival. The risk is that if indications of actual outcomes are weak and difficult to identify then the intensive competition among installers will induce greater pressures to degrade installation quality by underbidding to secure contracts or under performing relative to promised work quality. If certification proves to be a strong indication of actual performance, it may be an effective policy instrument to assure preferred contractor selection and that the former effects dominate. Consumers and SMI would then secure the available benefits of the surplus installer capacity and the selection among a larger pool of installers. Another possible policy approach is to provide sufficient supports to selected SMI applicants that these installers become rapid learners of improved methods and practices and they emerge as the better practice installers as a result of their greater industry experience. Without specifying the forms of support, this policy approach is more expensive. SMI would have to incorporate the cost of "training" before, during and/or after job performance. This approach increases the costs to SMI relative to the focus on the selection among installers that incurred training costs and/or were more effective learners from training and experience.

If selection among a surplus pool of installers is not well managed by selection of the better if not best practice installers then they are less likely to survive and continue operation in this industry for lack of adequate income. Furthermore, the intensified competition would likely result in the diminished quality of surviving firms and the possible diminution of industry reputation as the representative performance of installers more frequently disappoints both consumers and SMI. If selection among the surplus pool of installers is well managed, possibly through the use of certification as a selection factor, then the long term benefits will be a result of the survival of the more able installers in terms of their performance relative to cost. If poor performing installers are slow to exit the market place then this outcome even more strongly depends on adequate information and signals of superior installers for their selection among a continuing surplus pool of installers. If the surplus pool of installers are more generally performing at or near best practice (possibly all attaining certification and certification is a strong signal of a high quality of performance) then the benefits of intensified competition will accrue to consumers and SMI. This may be the outcome even over the long run if installers are slow to exit the market as they find lower than expected incomes from their installation activities. If a sufficient number of installers exit more quickly then the remaining installers will be in a more favorable position to maintain their income over the long run.

3.3.4 Pros and Cons of Training Options

The only two credible organizations that are presently offering training *with certification* (as opposed to simply providing a "certificate of completion") are NABCEP and GLREA. Our descriptions and conclusions are based upon the available published course literature and upon interviews with two of the principle proponents of these programs –Bill Brooks/NABCEP, Bob Pratt/GLREA. At this time we do not have specific course content for any NABCEP training programs, however what we do know is that the course content will likely follow the, now approved, NABCEP Task Analysis. What we know if the GLREA course structure and content comes their course syllabus[24] and our interview with Bob Pratt.

It appears that there are several major differences in the structure, orientation and pedagogical method of the two programs. Structurally the two training programs differ in that the NABCEP program only certifies one level of installer, while the GLREA program is two-tiered, with an apprentice level and a certified installer level. In the NABCEP program training is voluntary and optional. If you qualify to sit for the exam you have no obligation to participate in training. In the GLREA program a five-day training course is a mandatory requirement to sit for the apprentice exam. For the GLREA the certified installer exam training is at the discretion of the student.

[24] Please refer to Green Energy Ohio, http://www.greenenergyohio.org

Another difference between the two programs is in their orientation to training as it relates to the concept of design. The NABCEP program attempts to de-emphasize the role of systems design as reflected in its choice of language by referring to the process as, "Adapting the Mechanical Design," and "Adapting the Electrical Design." Their program assumes that "the installer begins with adequate documentation for the system design and equipment, including manuals for major components, electrical and mechanical drawings, and instructions."[25] This may simply be a matter of semantics. A great deal of the descriptive language under the headings of Adapting the ____ Design, –"identify a mechanical design, equipment to be used….", "identifying appropriate module/array layout, orientation….", "determining the design currents", "selecting appropriate conductor types and ratings….,"-- is, by any other name, system design. But NABCEP makes a deliberate decision to use this wording with the intent of distinguishing between the "installer as opposed to the system designer."

The professed objective of the GLREA program is to create entrepreneur integrators, competent in "all phases of the technology." The GLREA program has a distinct and deliberate emphasis upon the installer as a system designer. This is most evident in the form of student evaluation at the apprentice level. The final exam for the apprentice program is a take-home test requiring three complete system designs including a stand-alone system, a grid-tied system and a hybrid system. Each hypothetical system requires complete electrical and mechanical designs, as well as a business component, completed building and electrical permits, and a completed utility interconnection application. The preparation course and the exam for the certified installer entail advanced topics such as three-phase interconnection.

We feel that the degree of emphasis on "design" is important in Massachusetts because in building regulatory and inspection practices in the Commonwealth even simple construction requires a description of the proposed installation, often accompanied by a hand sketch, illustrating the intent of the design and the preliminary compliance to the applicable codes.[26] Most people in our industry recognize the distinction between, and the continuum from, installer to engineer/designer. However, as with small-scale construction and electrical installations, in the absence of stamped design drawings, the installer is ultimately responsible for the design of anything he or she installs and ultimately liable for any undesirable outcomes that are attributable to noncompliance with minimum safety codes and standards.

[25] Refer to Task Analysis, http://www.irecusa.org
[26] Conversation with Bruce Austin, Building Commissioner, Greenfield, MA, (past president Massachusetts Building Commissioners and Inspectors Association (MBCIA)) 3/25/03.

Finally, the two training programs appear to differ somewhat in their approach to teaching. The NABCEP training, assuming it resembles the FSEC model, which is accredited by ISP, will have a portion of the teaching done in a classroom environment and a portion done in either an indoor or outdoor laboratory.[27] The syllabus for the GLREA five-day apprentice program indicates two and a half days of class instruction and two and a half days of "hands-on" instruction. We have been told that the GLREA instructors attempt to coordinate training schedules with local installations when possible. In this regard the two programs appear very similar. However from a pedagogical perspective the distinguishing factor between the two comes down to the "design project" orientation embodied in the GLREA apprentice exam, as compared with the trade-craft focus of the NABCEP installer training.

The following table is a comparison of the advantages and disadvantages for the NABCEP and GLREA training programs. It is important to note that these conclusions and descriptions are based on very limited data because neither program has significant time in the field. To date the NABCEP program has not administered an exam to installers seeking certification (at least one pilot exam has been administered to a small group of subject matter experts.) At the time of our interview with Bob Pratt GLREA had held three apprentice classes with a total of approximately 34 students, and had held two advanced classes with a total of 13 students. Given the limited nature of the data some of the descriptions are likely to be highly subjective. We strongly encourage that further feedback be sought from both organizations. Recommendation on training options will be provide in the conclusion of the study.

[27] Some assumptions have to be made for the sake of this comparison because, to date, the NABCEP program has not been officially "launched."

Table 3. NABCEP/GLREA Training Comparison

	ADVANTAGES	DISADVANTAGES
NABCEP	• Widest national acceptance • Supported by NYSERDA • Has FSEC involvement • Has one accredited Master Trainer • Has/is developing standardized exam • Exam is strictly proctored (defensible) • Has "hands-on" component • Emphasizes worker safety, system quality & performance (based upon TA)	• Has not yet administered first exam to installers • Has no local or regional accredited facility • Has no entry level opportunity • Currently has only one Master Trainer in the US • Cost to sponsors or installers is unknown • Standardized test lends itself to "teach to exam" • Proportionally small (as stated in TA) emphasis on minimum safety designed for consumer safety
GLREA	• Has track record of training & exams • Has FSEC involvement • Has entry level & advanced level (mirrors Mass electrical licensure) • Emphasizes design & entrepreneurship • Has "hands-on" component • Apprentice program has creative, project-based teaching method. • Known cost: 5 day apprentice = $750, Systems Integrator course = $500-600 • Accepted for CE Credits by Ford-UAW	• Currently only in use in Ohio & Michigan • Details of the curriculum are unpublished • Apprentice exam is not proctored, is subjective, and the evaluation less "defensible" than standardized exam scoring

3.4 CERTIFICATION OPTIONS

We found that the only two viable options for PV installer certifications at this time are the NABCEP program and the GLREA program. We have studied the NABCEP program extensively and the GLREA to a lesser degree. Jim Bing has represented SEBANE at NABCEP meetings and was, until the commencement of this study, on the NABCEP Technical Committee. Bill Mass and Jim Bing attended a recent regional conference at the NYSERDA headquarters where NABCEP presented their program. In addition we have interviewed board members of both organizations. As with the training features of these programs, much of our understanding of the issues surrounding the certification processes are based upon the available published course literature and upon interviews held with Bill Brooks of Endecon Engineering, representing the NABCEP perspective, and with Robert Pratt of RGP Pro Inc., representing the GLREA program.

3.4.1 Procedural Requirements for Establishing PV Certification in MA

According to Gilley and Galbraith (Gilley and Galbraith, 1986), the following minimum steps should be taken when organizing a professional certification program:

1. Identify purposes and motives for the certification: Establish clear goals
2. Identify essential competencies for successful practice and/or the body of knowledge for the field
3. Establish certification procedures
4. Identify qualifications essential for prospective candidates
5. Respond to natural concerns of targeted groups
6. Establish certification criteria
7. Market the program
8. Evaluate and modify the program
9. Remarket the program

3.4.2 Analysis of NABCEP and GLREA Certification Programs

The NABCEP organization has taken a very formal path to establishing a training and certification program. They have or claim to have:

--Followed ISO/IEC standard 17024
--Used the National Organization for Competency Assurance to help define their standard
--Established a Task Analysis (posted on www.irecusa.org)
--Established a relationship with an accrediting entity (ISP)
--Established a curriculum and a relationship with a training organization (FSEC)
--Established a continuing education requirements
--Established written requirements to sit for the exam (posted on www.irecusa.org)
--PV Certification Exam Study Guide (in review)
--Candidate Information Booklet for PV Certification Exam (in review)
--Application for the PV Certification Exam (in review)
--Code of Ethics (in review)

The NABCEP organization has partnered with the Institute for Sustainable Power (ISP) in setting up the administration of the certification process and the accrediting of the associated institutions. NABCEP, through the work of its board of directors, its technical committee and its appeals to stakeholders, will write the certification exam. They have enlisted the assistance of Professional Testing, Inc., a Florida-based testing service, to provide the necessary independent validation of the certification exam. NABECP will then confer certification upon applicants that have passed the exam. ISP will accredit instructional providers (trainers and master trainers) to the standards established by NABCEP. ISP will also accredit instructional facilities and continuing education courses to NABCEP standards. Continuing education courses can be taken on a variety of topics related to the task analysis and do not require accreditation of ISP to qualify for credit. NABCEP is working with the Building Performance Institute in New York to manage the daily administration of their program providing such functions as coordination and administration of exams, collection of fees, logging of exam qualifications, and adjudicating disputes regarding evaluation and conference of certification.

NABCEP has aimed their efforts at a single level of trade persons. The NABCEP program currently has no entry level or apprentice category. Early, draft versions of the task analysis describe the demographic as, "Target Candidates for Certification: Person responsible for the system installation (e.g., contractor, foreman, supervisor, or journeyman)"[28] The core of their program is captured in the task analysis that was begun in the fall of 1998. The primary objective for the PV installer, as stated in the task analysis is,

> "Given basic instructions, major components, schematics and drawings, the PV installer is required to specify, configure, install, inspect and maintain a grid-connected PV system that meets the performance and reliability needs of the customer, incorporates quality craftsmanship, and complies with all applicable safety codes and standards by:
>
> 1. WORKING SAFELY WITH PHOTOVOLTAIC SYSTEMS
> 2. CONDUCTING A SITE ASSESSMENT
> 3. SELECTING A SYSTEM DESIGN
> 4. ADAPTING THE MECHANICAL DESIGN
> 5. ADAPTING THE ELECTRICAL DESIGN
> 6. INSTALLING SUBSYSTEMS AND COMPONENTS AT THE SITE
> 7. PERFORMING A SYSTEM CHECKOUT AND INSPECTION
> 8. MAINTAINING AND TROUBLESHOOTING A SYSTEM"

[28] This excerpt comes from the draft requirements for the NABCEP Task Analysis, NABCEP Installer RequirementsDraft2Oct18.doc

The task analysis was first conceived in a meeting of eleven subject matter experts in 1998. All of them were intimately familiar with the PV industry. Lacking from the list, among others, were representatives from the utility industry and from the inspectional community. The task analysis has since gone through ten revisions through distribution to stakeholders identified by the NABCEP organization.

GLREA has taken a much less formal approach to the organization of their certification program than NABCEP. They have established a curriculum and an organizational structure without having first created a formal task analysis. Four people that make up the GLREA Professional Certification Board designed the curriculum. This board answers to the GLREA Board of Directors. The Certification Board is made up of Robert Pratt (DTE utility background), Terence Parker (manufacturing background), John Witte (business and contracting background) and Debra Rowe (Education expert). When asked what would be the appeal process for an applicant that wished to dispute his or her test results we were told that the person could petition the Professional Certification Board, and, if unsatisfied, the GLREA Program Director, and finally the GLREA Board of Directors.

For its apprentice program GLREA requires only that applicant have, “some formal training on electricity.” This permits the entry-level applicant to enter the apprentice-training program and take the exam, which consists of a written test followed by three comprehensive design projects. If the applicant wishes, he or she may attempt to “test out” of the apprentice exam and by-pass the apprentice course, but this does not remove the requirement for comprehensive documented experience. Following completion of the apprentice exam requirements (test and design projects), the apprentice qualifies for work with PV systems integrators previously certified by GLREA. It is also possible for the apprentice to obtain experience elsewhere, but it must ultimately be validated by a GLREA certified integrator. This is an experience phase of the program whereby the apprentice obtains certifiable experience in all phases of systems design, installation and troubleshooting. Completion of the apprentice program exam, in combination with the documented work experience, earns the successful candidate a certificate of “Apprentice of Photovoltaic Systems Integration/Installation”.

Attaining the Apprentice of Photovoltaic Systems Integration/Installation certification is a prerequisite for taking the exam for System Integrator Certification. The applicant may then take the advanced course that can lead to System Integrator Certification. GLREA treats the experience requirements differently from NABCEP. They do not require that work experience be a precondition to sit for the written advanced exam, only that the applicant has passed the apprentice exam. In the GLREA program one can take the advanced exam and then, upon submission of documentation validated by a certified integrator of the installation of ten PV systems totaling 5 kW, the applicant receives a certificate of “Certified Photovoltaic Systems Integrator/Installer”.

It is the stated objective of the GLREA certification program to develop and validate “integrator” capabilities in its successful candidates, and to develop practitioners that are well-versed and experienced in design, maintenance and contractual business practices, as well as systems installation.

Table 4. NABCEP/GLREA Certification Comparison

	ADVANTAGES	DISADVANTAGES
NABCEP	• Widest national acceptance • Supported by NYSERDA • Has FSEC involvement • Has 1 accredited Master Trainer	• Has not yet been officially launched • Subject matter experts only from PV industry • Has no entry level opportunity • Not a substitute for electrical licensure in Mass
GLREA	• Has track record of training & exams • Has FSEC involvement • Has entry level & advanced level (mirrors Mass electrical licensure)	• Currently only in use in Ohio & Michigan • No task analysis was performed for curriculum • Very informal organizational structure • Not a substitute for electrical licensure in Mass

3.5 RECOMMENDATIONS

Given the broad nature of Massachusetts' legal definition of work categories that appear to subsume much of the scope of work commonly performed by PV installers, any recommendation pertaining to training and possible credential which falls outside of the formal state-sanctioned licensure structures may have little legal grounding in the Commonwealth and may be found to be, in many contexts, of questionable value. As a case in point, we believe that it is highly unlikely that any PV installer certification issued by a private organization would ever be recognized, for the purpose of job classification, on a public works/prevailing wage job. Neither would such a credential, by itself, enable its owner to pull any of the necessary permits needed to perform the work covered by its training. Nonetheless, given the generally perceived benefits of certification within a trade or profession, and especially in the absence of any state licensure program for PV installers, we recommend that the MTC begin a phased approach of engagement with NABCEP. We are recommending NABCEP over GLREA, principally on the merits of it administrative organization, its regional organizational strength, the legal defensibility of its program, and its efforts at establishing accreditation oversight. The MTC should enter into preliminary negotiations with NABCEP and begin a gradual, phased adaptation and adoption of their program for Massachusetts PV installers. Certification should be encouraged, but not made mandatory or a necessary condition for eligibility for MTC funded projects. NABCEP certification should be listed as *one* of several criteria that will be considered when evaluating grant proposals.

4.0 DISTRIBUTION COMPANY PERSONNEL TRAINING

4.1 KEY DISTRIBUTION COMPANY PERSONNEL

There are four investor-owned utilities (distribution companies) in Massachusetts. They are National Grid USA/Massachusetts Electric, NStar, Northeast Utilities/Western Massachusetts Electric, and Unitil/Fitchburg Gas and Electric Light Company. In addition to the four investor owned utilities there are also 40 municipal utilities, however this study has not surveyed these entities as they are not eligible for funding from the Renewable Energy Trust fund under the current legislation. Of the four investor-owned utilities the first three listed comprise the vast majority of the service territory in Massachusetts. Unitil's holding in the Commonwealth are limited to Fitchburg Gas & Electric and, at present, they have no PV installations in their Massachusetts service territory (See *Table 6. Key Distribution Company Personnel* for contact information).

Table 5. Key Distribution Company Personnel

Distribution Company	Contact Name & Title	Contact Info	Address
National Grid USA (Massachusetts Electric)	Dr. John Bzura Principal Engineer	508-303-7642 john.bzura@us.ngrid.com	National Grid USA Service Co., 55 Bearfoot Road Northborough, MA 01532
NSTAR (formerly Boston Edison & Commonwealth Electric)	Frank Gundal Senior Engineer	781-441-8151 Frank_gundal@nstaronline.com	1 NSTAR Way Southwest 340 Westwood, MA 02090-9230
Northeast Utilities (Western Massachusetts Electric)	Douglas Clarke Lead Account Executive	413-585-1726 clarkdp@nu.com	Western MA Electric 174 Bush Hill Ave. W. Springfield, MA 01090-2010
Unitil (Fitchburg Gas and Electric Light Company	John Bonazoli Manager-Energy Systems Engineering	603-385-1695 888-301-7700 bonazoli@unitil.com	Unitil FG&E 6 Liberty Lane West Hampton, NH 03842

4.2 DISTRIBUTION COMPANY FAMILIARITY WITH PV

We surveyed the person identified by each company as the point of contact for PV interconnection issues. All of the people that we surveyed expressed a high degree of confidence in the level of expertise of their staff with respect to the technical requirements of PV system review, inspection and approval. The experience deemed necessary for such work ranged from "BSEE or equivalent experience," to "minimal." The number of in-house people that the respondents reported to have relevant PV experience ranged from six to two. In most instances the highest concern was for an understanding of the company's own interconnection policy and standards. This was followed by the need to be able to identify/verify the UL listing of the inverter. All four of the companies have written interconnection policies and some have written application forms. The application process for the four companies is fairly uniform.

The respondents from NStar and Unitil said that they were unfamiliar with the MTC Cluster and Open Application programs. While the technical aspect of the interconnection process did not appear to pose a hurdle for any of the representative surveyed there were some concerns expressed regarding the burden to the utility. This comment came from one of the respondents:

"The issue is not with PV experience, the issue is with general interconnection experience. We have adequate experience in this area. The problem is not that we don't have qualified people to inspect installations, the problem is that most PV installations are done at no cost to the customer (under 10kW) If interconnections increase we will need to add staff to handle the load, however there is no mechanism to pay for them."

4.3 OPTIONS FOR OUTREACH TO DISTRIBUTION COMPANY PERSONNEL

Based on our surveys of key distribution company personnel there appears to be little need for additional training for utility staff. What needs there may be appear to be well within their in-house training capabilities. The MTC programs would benefit from a higher level of direct communication to the distribution company personnel charged with approving the system interconnections. We recommend that the MCT, in addition to their existing media coverage of grant awards and program announcements, institute a direct link to the four identified distribution company individuals by assigning a single MTC staff member as a utility liaison. This person would then make contact with each of the four effected companies, keeping them updated on initiatives underway in their service territories.

4.4 RECOMMENDATIONS

Each of the distribution companies has a standard interconnection policy. With exceptions of two items the interconnection applications are generally installer-friendly. The first exception to the standardized format for interconnection is for systems proposed for installation in network grids. These distribution areas are primarily restricted to a few large urban areas such as downtown Boston and Worcester. In these areas additional engineering analysis and relay protection is required before interconnection is permitted. The second exception to standard interconnection policies is for larger systems with ratings of 10 kW or more. These typically will also require a higher level of design and more extensive interaction with the effected distribution company.

For the majority of systems being installed under the cluster and open application program we recommend that installers simply contact person at the distribution company in question (listed above) and request the current version of that distribution company's interconnection application. For those systems that are proposed to be installed in areas serviced by network grids or where the proposed installations are larger than 10 kW, we again recommend that the MTC refer applicants to the appropriate contact person at the distribution company in question and recommend that they seek professional assistance through the membership list of the Solar Energy Business Association of New England (SEBANE). Most of these concerns are likely to become moot if and when state-wide interconnection standards are adopted. The new standard includes a decision matrix designed to definitively identify an applicants interconnection requirements based upon a simple set of questions. These draft standards are being reviewed at this time by the Department of Telecommunications and Energy (DTE).

5.0 ELECTRICAL AND BUILDING INSPECTORS[29]

5.1 FAMILIARITY OF INSPECTORATE WITH PV

We surveyed 75 of the approximately 450 electrical inspectors (17%) and 94 of the 674 building officials (14%) in the Commonwealth.[30] Based on the survey results it is clear that the majority of electrical and building inspectors have little or no familiarity with photovoltaic technology. Our survey results confirm the widely held belief among PV installers, which is supported by the findings in the report, "Massachusetts Residential PV Installation Barriers & Development, Survey of Installations Massachusetts Electric Co., Western Massachusetts Electric Co., PV Pilot Programs" by BVPS, that "The majority of Building Departments have yet to see the first permit application for a photovoltaic system in their jurisdictions."

That said, both the community of electrical inspectors and that of building inspectors and commissioners are well organized, involved in routine –mandated- continuing education, and possess highly effective and engaged

[29] We define the term "building officials" as either Inspector of Buildings/Building Commissioner or Local Inspector specified by the Board of Building Regulations and Standards (BBRS). Building officials are required to meet minimum standards of education and experience as stipulated in Massachusetts General Laws, c 143 s 3, and to be certified by BBRS in the capacity in which they serve. Certification is by qualification of experience in accordance with MGL c 143 s 3 and by specific series of examinations. Once certified, building officials must complete 45 hours of approved continuing education in every 3 year period. As of today, a total number of 724 building officials have been certified in Massachusetts. 674 building officials are currently working, among which 545 are certified. (Note there are 129 uncertified building officials in the state. They are conditionally appointed by municipalities and are required to conclude the certification process by successfully completing the examination process and applying for and being awarded certification within 18 months of the date of appointment.) We have chosen to use the more familiar term, Building Inspector, simply as a means of following the form of the original RFP

professional organizations. In both communities mechanisms exist, both formal and informal, to disseminate information about new technologies and the pertinent electrical and building code articles. Both electrical inspectors and building officials are already required to attain a number of hours of continuing education. These requirements are mandated by the state and their various professional organizations work to make those educational resources available to them. In addition, informal colleague networks provide resources that individuals can call upon for interpretation and advice.

5.1.1 Electrical Inspectors Familiarity

Of the 75 inspectors surveyed, while 55 said that they had access to a Massachusetts Electric Code expert however only 2 reported that they knew of or had access to a PV expert. Twenty of the pool of respondents said that they had experience inspecting forms of distributed generation but only six of those were PV installations. Only ten of the inspectors said that they had taken part in a discussion of Article 690, however 61 reported that, if PV systems became more prevalent in their jurisdictions, they would be interested in participating in a course on photovoltaic technology.

In the survey we asked the inspectors how they learn about and keep abreast of new technologies. In addition to asking about the method and sources, such as trade periodicals and professional organizations, we asked about human resources that were available to them. What we found is that there is a small core of experts within the state. The respondents identified them by name.

5.1.2 Building Inspectors Familiarity

Of the 94 building commissioners and local inspectors that we surveyed only 11 said that they had access to an expert resource on PV installation technology. Sixteen said that they had experience inspecting solar hot water systems but only 6 reported having ever discussed article 3622, solar systems, in 780 CMR. When asked if they would consider participating in a Code workshop, should PV installations become more prevalent in their jurisdiction, 89 responded that they would be interested.

5.2 EFFECT OF INSPECTOR'S KNOWLEDGE OF PV ON INSTALLATIONS AND ON THE SMI PROGRAM

The level of familiarity with PV on the part of either or both the electrical and building officials can be a significant factor in cost of a photovoltaic installation. It is common practice that a PV installer will have to provide a "PV primer" to the electrical inspector. In the absence of clear understanding of photovoltaic

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[30] For details of the survey responses of the electrical inspectors and building officials see Appendix 5: Inspector Surveys.

technology and the MEC requirements (electrical inspectors) and aspects of 780 CMR (building officials), the inspector will often rely on accepted practices and requirements for other, more familiar equipment and circuitry. This can add needless expense without increasing system safety or performance. Examples of this problem are described in some detail in the MTC report, "Massachusetts Residential PV Installation Barriers & Development, Survey of Installations Massachusetts Electric Co., Western Massachusetts Electric Co., PV Pilot Programs" by BVPS.

Building officials have an even greater problem than their electrical inspector counterparts. There is no specific reference to photovoltaic installations in the Massachusetts Building Code, 780 CMR. There is an article that details the requirements of solar thermal system, however this is only marginally applicable to PV. In the absence of an article dedicated to PV installations in 780 CMR inspectors must resort to "first principals" in analyzing the requirements for each individual installation. It may be because of this lack of specificity in the building code that many municipalities do not require a building permit associated with the electrical permit for PV installations. In an interview with Bruce Austin, the Greenfield building commissioner and past president of the Massachusetts Building Commissioners and Inspectors Association (MBCIA), when asked if a PV system was a "structure" and thus required a building permit, he said that, "It is definitely a structure. It sees a wind load, therefore it is a structure." He went on to say, "Refer to Article 2, definitions, of 780 CMR, Mass State Building Code." The problem, Mr. Austin goes on to say is that, "780 CMR gives no guidance! There is precious little information in the building code that tells an inspector what he or she should do." Whether the installation is a roof-mount, a sidewall mount or a ground mount system there is very little in the code to rely upon. Technically a violation of the building code is not a violation until the inspector returns to his or her office after the inspection and writes a letter to the builder sighting chapter and verse in the building code that details the nature of the violation. Right now there is very little there to go on."

The effect that this will have on the SMI is to create confusion and increased transaction cost for installers working in multiple jurisdiction.

5.3 DEFINE TRAINING OPTIONS FOR INSPECTORATE

5.3.1 Electrical Inspectors Training

In order to qualify for a position as an electrical inspector, individuals are required to maintain their electrical license. This requires 15 hours of Massachusetts Electrical Code (MEC) update every three years (this term coincides with the publication cycle of the MEC). In addition the Board of Examiners of Electricians has added a requirement for six hours of continuing education on any trade or business related topic. This is no different than the requirements for all of the other electricians in the Commonwealth except that the electrical inspectors are required to complete their training within the first six months of the new Code cycle. The newly mandated six additional hours of continuing education could offer an excellent opportunity to reach this community. Our survey has identified several of the most prominent Code experts, as recognized by their peers, in the Commonwealth. Several of these individuals, besides being inspectors, are in the business of providing training services to meet the mandated electrician's continuing education requirements. This ready-made training forum could be an excellent delivery mechanism for the portions of the Code that pertain to photovoltaics.

5.3.2 Building Inspectors Training

The State Board of Building Regulation and Standards (BBRS) requires building commissioners and local inspectors to have 45 continuing education credits during each three-year term. Those credits are divided into ones that are strictly defined by the state and others that may be delivered by outside providers. The courses and training offered by outside providers are reviewed by BBRS and given a value in contact hours. The building officials' professional organizations –Massachusetts Building Commissioners and Inspectors Association (MBCIA), the Southeastern Massachusetts Building Officials Association (SEMBOA), and the Building Officials of Western Massachusetts (BOCA Chapter 66)— bring guest speakers to their monthly meetings for the purpose of meeting the state mandated continuing education requirements. Again, as with the electrical inspectors, there exists a ready-made forum for the delivery of training and education on the building code issues that pertain to photovoltaic installations.

5.4 RECOMMENDATIONS

There are already training systems in place designed to keep both electrical and building officials abreast of changing technology. We recommend that the MTC work within these existing structures to reach these communities. The benefits of this approach include the cost savings associated with the use of an existing of the pedagogical infrastructure. In addition we believe that this approach will foster a sense of inclusion for the inspectorate community (compared with pursuing a parallel competing educational track) and will better integrate with the Code making and regulatory structures of the Commonwealth.

As a possible augmentation to the approach of working within the state mandated continuing education framework, we also recommend that the MTC consider a stipend for a focused training session for the Mass Electric Code experts identified by our survey. This small group of experts serves as an informal resource to the larger community of electrical inspectors and we believe that, properly prepared, they could be a highly leveraged asset.

6.0 TRAINING AND CERTIFICATION PROVIDER REQUIREMENTS, RESPONSIBILITIES AND QUALIFICATIONS

Many certification programs are established to comply with the requirements of various accrediting bodies to ensure that they are formulated, implemented, and regularly evaluated according to the highest educational and professional standards. Just as university programs must be "accredited" to ensure that they are formulated and implemented in keeping with good quality standards—a notable example is the American Assembly for Collegiate Schools of Business (AACSB) for business schools and the North Central Association for schools—so too should other certification programs be linked to a body that establishes professional standards for the practice of certification.

6.1 ADMINISTRATIVE CAPABILITIES

Typically, a certifying body must at least be capable of keeping records, authorizing and funding occupational studies of the group for which they provide certification, and administering tests and other evidence of individual accomplishment. A certifying body may undertake and deliver training on its own or else authorize others to do so on its behalf.

6.2 AVAILABLE APPROACHES TO TRAINING AND CERTIFICATION

According to Judith Hale in *Performance-based certification: How to design a valid, defensible, cost-effective program* (San Francisco: Jossey-Bass, 2000), any certification program must answer all the journalistic questions: (1) who is it targeted to, and who will issue the certification? (2) what are the key procedures governing the certification? (3) when will individuals be certified? (4) where will the certification be conducted? (5) why is the certification established? (6) how will the certification process work?

A key issue in certification is the assessment or demonstration of competence. Of course, competence may be demonstrated in various ways. While many people may associate paper-and-pencil exams with certification—such as the Certified Public Accountant (CPA) exam—the fact is that competence may be assessed through such approaches as measures of previous education, training, and experience, tests of knowledge or tests of performance, work samples, work or personal records, endorsements by others known to be competent, and external credentials (Hale, 2000).

6.3 QUALIFIED TRAINING ORGANIZATIONS

It is not uncommon for a certification body to establish a training component to help its members prepare for examinations and/or meet other standards to become qualified in the field. Most certification efforts are overseen by a Board that ensures the professional operation of the certification program. One task of the Board is to ensure that "test preparation training" is designed, developed, delivered, and evaluated in professional ways that comply with good business practice. Some groups associated with certification—such as the American Institute for Certified Public Accountants—actually issue guides to ensure that each State conducts professional certification efforts. They also publish guides for providers of continuing professional education, whether geared to help people become certified or to retain certification through compliance with the provision to recertify periodically, to ensure that the "training" is professionally prepared.

Professionally prepared training is prepared according to the so-called Instructional Systems Design (ISD) approach, widely practiced by U.S. business and invented by the U.S. military. Such training is based on a systematic approach:

1. Learning needs are clearly and systematically identified.
2. Targeted learners are screened.
3. The training is linked to the real-world conditions found when practicing the occupation.
4. Instructional objectives to guide the training are established and, when they are met, so are the learning needs.
5. Tests are based on instructional objectives, which are (in turn) based on the results of job, task and/or competency analysis.
6. Instructional materials are selected, prepared, or selected and modified to help meet the objectives and help learners pass the test.
7. Instructional materials are tested on a small group prior to widespread delivery.
8. Delivery media are selected to foster learning.
9. Delivery methods are appropriate for the material, methods, and learners.
10. Results are tracked.

These or similar standards are the basis for many academic programs in employee training and in the field known as "instructional design." (Rothwell & Kazanas, 1998)

6.4 RECOMMENDATIONS

The preferred approach to providing training and certification for PV installers is to create a regional resource center with a training provider with established programs of training and certification in a related field, such as electrical apprenticeship. Furthermore, it is recommended that MTC encourage one or more instructors attain ISP certified PV Trainer status (possibly subsidizing instructor training) and MTC support the training provider efforts toward attaining ISP accreditation. This approach has several immediate advantages:

- The institution has the administrative mechanisms in place for recording and verifying program compliance

• Much of the laboratory infrastructure investment needed to demonstrate and teach electrical (PV) wiring has already been made[31]

• The pedagogical methods appropriate to teaching tradecraft are established and understood. These institutions are already skilled in delivering training that is a combination of the basic theory upon which a technology is based, the practical hand-on skills that daily practice of the craft demands, as well as the regulatory standard(s) with which all work must comply.[32]

• These institutions are already equipped to deal with the liability issues that are necessarily a concern of any training that incorporates a laboratory component

The question that then arises is where to locate such a center. The driving consideration should be, first to make such a resource available to installers based in Massachusetts, and second to consider its place in the regional economy and its accessibility to the wider community of installers who wish to offer services in the Commonwealth. The MTC might also explore economies of scale in training options afforded by regional opportunities in New York and throughout New England. Overtures should first be made to other states that already have reciprocal electrical license arrangement with Massachusetts (VT, ME, NH).

[31] Mark Fitzgerald of ISP estimates that the cost savings achievable by working with a provider with an established facility could be between $20,000 and $30,000 per accredited site.

[32] In the example of the related vocational program of electrical apprentice training, education in the Massachusetts Electrical Code figures significantly.

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8.0 APPENDIX

APPENDIX 1: GLOSSARY of ACRONYMS & DEFINITIONS

8.1 ACRONYMS

AACSB ---American Assembly for Collegiate Schools of Business

ABC ---Associated Builders and Contactors

ABET ---Accreditation Board of Engineering and Technology

AIA/AAI ---American Insurance Association / Alliance of American Insurers

AGC ---Associated General Contractors of America

ANSI ---American National Standards Institute

BOCA ---Building Officials of Western Massachusetts

BPI ---Building Performance Institute

BBRS ---Board of Building Regulations and Standards

CEC ---California Energy Commission

CMR ---Code of Massachusetts Regulations

EPRI/E2I ---Electrical Power Research Institute & Electricity Innovation Institute

FSEC ---Florida Solar Energy Center

GLREA ---Great Lake Renewable Energy Association

GMPLA ---Government Mandated Project Labor Agreements

HBI ---Home Builder’s Institute

IAEI ---International Association of Electrical Inspectors

IBEW ---International Brotherhood of Electrical Workers

IEEE ---Institute of Electrical and Electronics Engineers

IREC ---Interstate Renewable Energy Council

ISD ---Instructional Systems Design

ISO/IEC ---International Standard Organization (Guide 17024)

ISP ---Institute of Sustainable Power

JCAHO --- Joint Commission on Accreditation of Healthcare Organizations

LIPA ---Long Island Power Authority

MBCIA ---Massachusetts Building Commissioners and Inspectors Association

MEC ---Massachusetts Electrical Code

MGL ---Massachusetts General Laws

NABCEP ---North American Board of Certified Energy Practitioners

NASCLA ---National Association of State Contractors Licensing Agencies

NCCER ---National Center for Construction Education and Research

NECA ---National Electrical Contractors Association

NFPA ---National Fire Protection Association

NJATC --- National Joint Apprenticeship and Training Committee

NPCSCP ---National Photovoltaic Construction Standards & Certification Partnership

NREL ---National Renewable Energy Laboratory

NYSERDA ---New York State Energy Research and Development Authority

OSHA ---Occupational Safety and Health Administration

SEBANE ---Solar Energy Business Association of New England

SMI ---Solar to Market Initiative

SRCC ---Solar Rating and Certification Corporation

SWTDI ---Southwest Technology Development Institute

UL --- Underwriters Laboratory

8.2 DEFINITIONS

Competence: The common understanding of competence is that an individual who demonstrates it is able to perform to an acceptable standard or according to norms of practice.

Certificate: A certificate is a document awarded for completion of a program. People who attend training are often awarded a certificate of achievement, a certificate of participation, or a certificate of completion. A certificate does not imply a demonstration of competence; rather, it suggests the completion of an educational program only. When an individual completes a certificate, it means that he or she has participated in an educational program. However, no guarantee of competence is implied.

Certification: A certification is a credential awarded by an employer, a vendor, or an association or an independent agency. A certification is also a designation given to people, products, or processes that have satisfied a set of standards. (Hale, 2000)

Certification often carries with it the implication that the certifying body is guaranteeing the individual=s competence.

Recertification: The process of demonstrating continuing adherence to standards over time. Individuals, organizations, or processes may be recertified, but the term is most often associated with a procedure by which individuals demonstrate that they have maintained up-to-date knowledge and skills and usually involves satisfying continuing professional education requirements.

License: AA license is a credential awarded by a state government or its authorized agent. Licenses permit individuals to practice a profession or use a title in association with their work. Not all professions or titles are licensed. Examples of professions that are licensed are medical doctors, dentists, dental hygienists, nurses, nurse anesthetists, dieticians, beauticians, barbers, real estate brokers, cosmetologists, and interior designers (Hale, 2000).

Accreditation: AAn accreditation is a credential awarded by a nongovernmental association that regulates academic programs, specialized education, and training offered by universities, colleges, trade schools, and vendors. (Hale, 2000).

APPENDIX 2: GENERAL LAW of MASSACHUSETTS

General Laws of Massachusetts (MGL)

This is the home page for the General Laws of Massachusetts:
http://www.state.ma.us/legis/laws/mgl/

This is the law governing supervision of electricians:
http://www.state.ma.us/legis/laws/mgl/gl-141-toc.htm

This is the Definitions section:
http://www.state.ma.us/legis/laws/mgl/141-1.htm

This is the section on licensing requirements:
http://www.state.ma.us/legis/laws/mgl/141-1A.htm

This page adopts the requirements for inspections of electrical work:
http://www.state.ma.us/legis/laws/mgl/143-3L.htm

Code of Massachusetts Regulations (CMR)

This is a link to many (possibly all of the web-published) CMR:
http://www.lawlib.state.ma.us/200-299cmr.html

This is a link to 237 CMR, the code governing licensing of electricians and rules of practice for electricians:
http://www.state.ma.us/reg/boards/el/cmr.htm

This site may be used to select and link to 527 CMR 12.00, the Massachusetts Electrical Code (note that the version here is dated 1999 and the current version is the 2002 code). The Massachusetts Electrical Code is, in reality, the National Electrical Code (NEC), which is published by the National Fire Protection Association, with a very few pages of exclusions and additions.
http://www.state.ma.us/dfs/cmr/cmridx.htm

Other relevant regulations are included in 780 CMR, the Board of Building Regulations and Standards (BBRS) Massachusetts Building Code. That is not available on the web.

APPENDIX 3: PV TRAINING & CERTIFICATION INITIATIVES

See electronically attached items:

- PVTrainingIniatitive-update02-0103.xls
- State Summaries of Certification-3-7-03.xls
- AN ACT CONCERNING SOLAR WORK.htm
  General Assembly Raised Bill No. 1114 (An Act Concerning Solar Work)
- UMass Lowell Solar Energy Engineering Masters Program
  http://chemical.caeds.eng.uml.edu/research/researchmain.htm
- GLREA Course Description http://www.greenenergyohio.org
  GLREA course default.cfm_exec=Page.pdf
- NABCEP Task Analysis, Approved 6/4/02 http://www.irecusa.org
  Task Analysis 20614.pdf

See links for related licensure in other states:
Florida:
http://www.bocc.citrus.fl.us/building/chap489.htm
California:
http://www.cslb.ca.gov/licensing/c46.asp
Oregon:
http://www.leg.state.or.us/orlaws/sess0300.dir/0392ses.html

APPENDIX 4: NEW ENGLAND PV WORKFORCE

See attached documents:

- NortheastPVIndustryContact.xls
- Derived demand for installers 1.doc

APPENDIX 5: PV INSTALLER & INSPECTOR SURVEYS

See attached surveys:

Building Inspector Survey.doc

Electrical Inspector Survey.doc

PV Installer Survey.doc

See attached spreadsheets:

MunicipalBldgInspectorSurveyResults.xls

ElectricalInspectorSurveyResults.xls

InstallerSurveySummaryData.xls