SKILL NEEDS FOR THE SOLAR ENERGY WORKFORCE

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1. Abstract

The International Renewable Energy Alliance (REN-A), in collaboration with the United Nations International Labour Organization (UN-ILO) recently completed a report on skill needs for renewable energy to help direct further support for training programs and policies worldwide. ISES developed the solar energy component which included a description of the multi-tiered nature of the solar workforce; the solar industry growth and the implications for workforce development in different parts of the world; how people are developing the needed skills to fill these jobs and how training varies across countries; and recommendations for improving the workforce. Findings for the solar sector are based primarily on reviews of existing assessments, supplemented with results from interviews and/or surveys from training providers, businesses, and associations. This paper draws from the REN-A/UN-ILO effort, highlighting the key recommendations for accelerating the development of a growing qualified solar workforce.

The solar sector workforce includes jobs mainly in manufacturing and installation for all aspects of active solar, with some variation in the skills required for dealing with small and large scale PV, solar thermal, and large scale solar thermal or concentrating solar thermal (CSP). Architecture is the primary passive solar job category, yet architecture and building fields also include active solar technologies. For all solar businesses, there are related jobs in site selection analyses, engineering and design, sales, marketing, business development, management, and other general administrative activities. As the solar energy sector continues to grow, so too will the need for comprehensive multi-tiered workforce development and quality training for that workforce.

The solar industry has recorded unprecedented growth over the last few years and this has resulted in considerable growth in jobs. Given rapidly rising interest in solar energy alternatives and expected production growth, future years may well see worldwide employment soar—to possibly as high as 6.3 million jobs in solar PV alone by 2030. Government policies, investments, and consumer demand are key to driving and supporting job creation in solar energy. Favourable policies and investments are leading to more product development and use, and a commensurate increase in demand for skilled jobs. Access to clean renewable energy in remote, developing areas is becoming a direct driving force for products, and for skilled workforce development to install and maintain them.

The needs for skilled workers are being addressed mainly by organizations dedicated to training aimed at one or more core occupations and by academic institutions providing various levels of educational opportunities for solar professionals be they highly skilled installers, researchers, engineers, or other technical workers. In addition, some corporations are providing in-house training, primarily for people responsible for various aspects of installation. Skills development varies from country to country: some countries have a variety of institutions offering courses and certifications; while other countries are only starting to see the emergence of training and educational institutions beginning to offer specialized training.

The lack of high quality standards in installation and manufacturing that are applicable across countries is a major concern recognized for all parts of the sector. There is a crucial need for qualification schemes across countries to guarantee product manufacturing and installation processes are of highest quality regardless of where the products are made and the installations take place.

2. Multi-Tiered Solar Workforce

2.1 Scope

Solar energy, derived from the sun's visible light, has been harnessed by humans since ancient times using a range of ever-evolving technologies. Only a very tiny fraction of available solar energy is used. In addition

to solar electricity, a partial list of other solar applications includes space heating and cooling through active technologies and passive solar architecture, potable water via distillation and disinfection, day lighting, solar hot water, solar cooking, and high temperature process heat for industrial applications. Solar technologies are broadly characterized as either passive solar or active solar depending on the way they capture, convert and distribute solar energy. Active solar refers to the use of photovoltaic panels and solar thermal collectors to harness the sun's energy. Passive solar include techniques mainly focus on orienting a building to the sun, selecting materials with favourable thermal mass or light dispersing properties, and designing spaces that circulate air naturally.

The active solar energy business sector is composed mainly of photovoltaic and solar thermal with applications ranging from individual small-scale installations to large-scale utility applications. Passive solar design also is considered as part of the solar energy business sector. The solar sector workforce includes jobs mainly in manufacturing and installation for active and architecture for passive, plus related jobs in site selection analyses, engineering and design, sales, marketing, business development, management, and other general administrative activities. As the solar energy sector continues to grow, so too will the need for comprehensive multi-tiered workforce development and quality training for that workforce.

2.2 Value chains

For the active solar side, which deals mainly with production and installation of PV and solar thermal, there are distinct segments of the value chain, starting from the manufacturing of equipment and module production all the way to the installation and operation. Among them are also activities that span the whole lifecycle such as consulting, testing and financing as well as publishing and training. The main aspects of the manufacturing process are acquisition of raw materials, and manufacturing of cells, modules, mounting and tracking systems, and various related electrical components. Services include project development, wholesale distribution, design, engineering, construction and maintenance.

Passive solar technologies can often also incorporate active PV and solar thermal products. Also, as with the active solar value chain, the passive solar includes the general components of financing, consulting and testing.

As in any business endeavour, all of the solar sector businesses rely on strong support in sales, marketing, business development, management, human resource development, and other administrative activities. All of these major aspects of the value chains for the solar sector are summarized in the following figure.

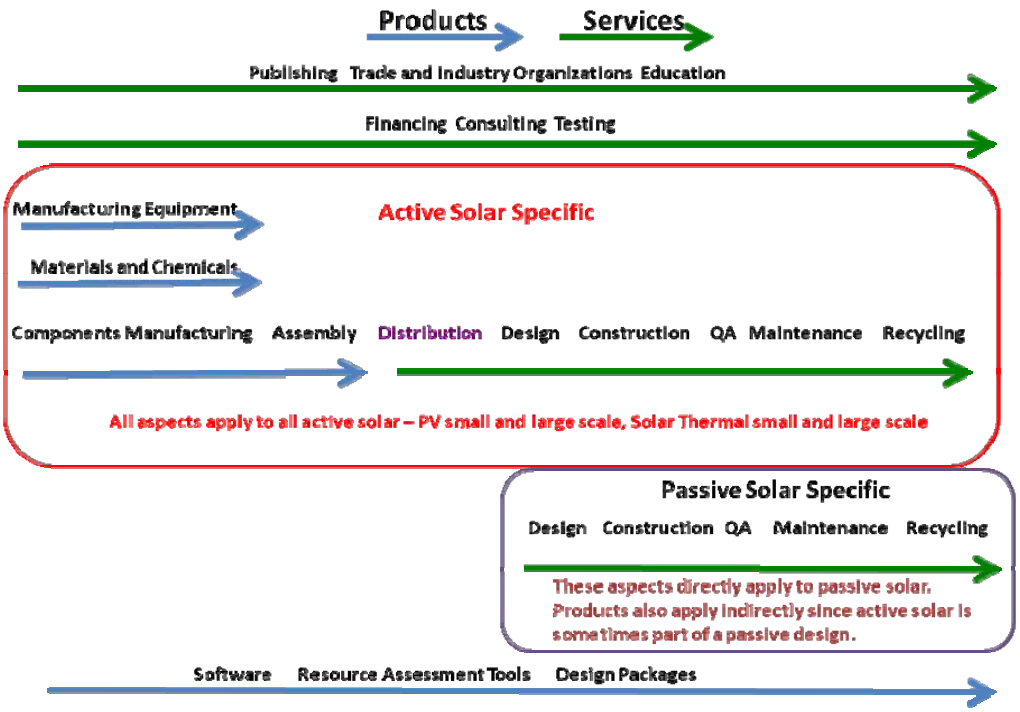


Fig. 1. Solar value chains and jobs

The spectrum of skills required in the solar sector is extensive, ranging from PhD level professionals in R&D to "green" collar technicians requiring specialized training and certification, to a wide variety of types of job responsible for supporting all aspects of the solar industry. These jobs span a wide array of skills, educational backgrounds, and occupational profiles. Even for new industries like solar, there is still need for the more general jobs associated with any business. For many of the technical jobs, special training is needed. For all of the directly related solar energy industry jobs, some level of understanding of the value and complexity of the solar energy technologies and business climate are useful.

The following provides a sense of the scope of jobs currently in the solar sector. The following code regarding skill level is used:

H = High skilled – Professional / managerial; M = Medium skilled – Technician / Skilled Manual / Supervisory; L = Low – Semi-skilled and Unskilled

Jobs in the cross-cutting enabling activities are not specific to solar. Jobs in the other categories are more directly related to the solar industry. Workers in these areas can be directly trained in solar or can be people who have been retrained or further trained to work in the solar sector.

Tab. 1 Occupations in the solar energy sector

Equipment Manufacture (Including Design)	Construction and Installation	Operation and Maintenance
R&D/DESIGN Manufacturing Specialists (H,M) R&D Chemists, Physicists, Engineers (H) Building Systems Specialists (H) Modellers (H) **QA/QC** Manufacturing Quality Assurance Experts (H,M) **MARKETING/SALES/DELIVERY** Equipment Transporters (L) Marketing Specialists (M,H) Sales Personnel (M<H) **PRODUCTION** Assembly line workers (L,M) Managers (M,H)	**PLANNING/DESIGN** Architects (H) Project Designers & Managers (H) Resource Assessment Specialists (H) **CONSTRUCTION/INSTALLATION/QA/QC** Site, Project and Installation Evaluators (H,M) Project Managers (H) Construction Professionals (H,M,L) Installers (M) Electricians specializing in Solar (M) Plumbers Specializing in Solar (M) Roofers Specializing in Solar (M) Welders (M) Pipe Fitters (M) Sales Reps Trained in Solar (H,M)	**O&M** Engineers (H) Recycling Specialists (H) QA Specialists (H,M) Maintenance Workers (L) Maintenance Specialists (M) Electricians Specializing in Solar (M) Plumbers Specializing in Solar (M)
Cross-Cutting/Enabling		
Educators &Trainers (H) Atmospheric Scientists & Meteorologists (H) General Marketing, Business Developers (H,M) Human Resource Developers, Administrators, Office Managers (H,M,L) Publishers and Science Writers (H,M) Software Engineers (H,M) Lawyers, Government Program Developers/Facilitators (H,M) Society and Trade Association Leads and Staff (H, M,L)		

In terms of further breakdown into jobs that are related to small and large scale PV (SPV,LPV), solar thermal (ST), concentrating solar (CSP), and passive solar (PS) jobs, the following generalizations can be made:

- Equipment Manufacture – All jobs apply to SPV, LPV, ST, CSP
- Operation and Maintenance– All jobs apply to SPV, LPV, ST, CSP
- Cross-cutting Enabling – All jobs apply to SPV, LPV, ST, CSP, PS
- Construction and Installation –
    - Architects (H) – PS, SPV, LPV, ST
    - Project Designers & Managers (H) – SPV, LPV, ST, CSP
    - Resource Assessment Specialists (H) - SPV, LPV, ST, CSP
    - Site, Project and Installation Evaluators (H,M) - SPV, LPV, ST, CSP, PS

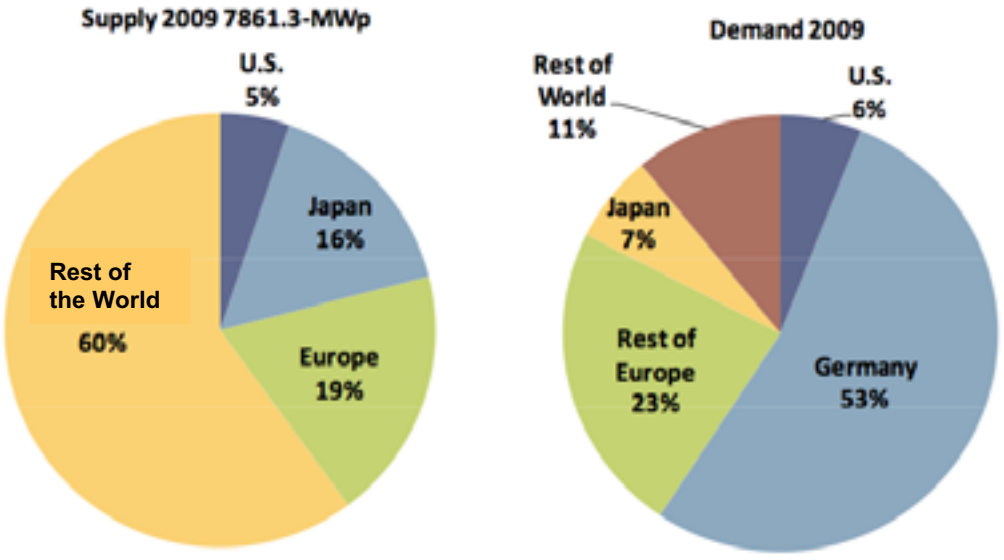
- Construction Professionals (H,M,L) - SPV, LPV, ST, CSP, PS
- Installers (M) – SPV, ST
- Electricians specializing in Solar (M) – SPV, LPV
- Plumbers Specializing in Solar (M) -- ST
- Roofers Specializing in Solar (M) – SPV, ST
- Welders (M) -- CSP
- Pipe Fitters (M) -- CSP
- Sales Reps Trained in Solar (H,M) – SPV, LPV, ST

3. Workforce Needs Across Countries

3.1 Job Creation and Solar Sector Growth

Recent trends reflect strong growth and investment across the solar sector. Grid-connected solar PV has grown by an average of 60 percent every year for the past decade, increasing 100-fold since 2000. During the past five years from 2005 to 2009, solar hot water grew by 19 percent annually. (Renewable Energy Policy Network for the 21st Century). All indications show this growth will continue, as saturation has yet to be reached in any area. As the solar energy sector continues to grow, so too will the need for comprehensive multi-tiered workforce development and quality training for that workforce.

Recent trends in supply and demand worldwide, illustrated in the figure below, show an imbalance between countries producing products and countries demanding them. This is particularly the case for PV systems where the increase in demand for PV is occurring in one set of countries and the increase in supply of PV is occurring in a different set of countries. While this imbalance has implications for manufacturing jobs, installation of equipment in a particular country typically draws from the workforce in that country.



(Source: Navigant Consulting, 2009) Navigant Consulting, Inc. PV Services Program
http://www.navigant.com/industries/energy/renewable_energy/solar_services_program/

Fig. 2 Supply and demand, 2009

Solar sector changes are happening at a rapid pace and this has implications for the workforce. The solar industry today is different than what it was just a year ago. Some countries are experiencing pockets of exponential growth while other areas within the same country are showing much slower growth. For example, in the US, state-wide efforts to increase the use of solar power vary considerably. As a result, some areas of high demand do not have adequate numbers of qualified installers.

On the production side, there will continue to be a push for more R&D and qualified staff in production development. This in turn will underscore the need for commensurate professional education.

3.2 Building the Workforce

Employment in the solar energy sector will be affected in several key ways as the world moves toward a more renewable energy based economy. Some jobs will be substituted as the shift from fossil fuels to solar energy takes place and many existing jobs (e.g., especially vocations such as plumbers, electricians, metal workers, and construction workers) will be transformed and redefined as day-to-day skill sets, work methods, and profiles shift with the new solar specific tasks and general workplace operations in the solar sector.

Rapid growth in jobs directly related to the solar industry illustrates that the transition is well underway, with over 2 million jobs in the industry in 2006 and many more today.

Tab. 2 Job Estimates for the world and for several selected countries

Solar PV	170,000**	China Germany Spain United States	55,000 35,000 26,449 15,700
Solar Thermal	624,000-plus	China Germany Spain United States	600,000 13,300 9,142 1,900

** The worldwide numbers were derived under the assumption that Japan's PV industry employs roughly as many people as Germany's PV industry. Source: UNEP 2008 Green Jobs.

These figures underestimate the current situation as the quality of employment figures varies from country to country. Plus, many jobs indirectly related to the industry are not included in these statistics (UNEP/ILO/IOE/ITUC. 2008).

A striking increase in estimates is noted in the newly released "National Solar Jobs Census 2010: A Review of the U.S. Solar Workforce" which identified more than 16,700 solar employment sites and 93,000 solar jobs in all 50 states. Additionally, the report found that solar employers expect to increase the number of solar workers by 26 percent, representing nearly 24,000 net new jobs by August 2011 (http://www.seia.org/cs/news_detail?pressrelease.id=1074).

Growth of the solar industry is creating high-skilled to low-skilled jobs in areas specialized on solar energy as well as in general job categories. For example, high-wage, skilled jobs are growing throughout a number of countries for individuals with many different types of training. R&D groups at national laboratories, universities, and private companies develop and continually improve solar products to lower their costs and improve their reliability. Individuals employed in solar R&D generally have professional degrees in electrical, mechanical, and chemical engineering; materials science, and/or physics. Many of the people involved with technologies that are still under development focus on R&D.

As each technology progresses from the R&D phase toward full-scale commercialization, an increasing number of both professional and skilled workers are needed to sell, manufacture, design, install, and maintain equipment. The PV and solar hot water industries currently employ the majority of these workers, including electricians, engineers, technicians, and technical managers. Utility-scale concentrating solar power technologies also require an increasing number of these workers, as well as engineers and construction workers to design and build power plants. The passive solar industry involves many of the general professions as well, and also employs architects and builders.

A US Solar Jobs Census 2010 (http://www.thesolarfoundation.org/research/national-solar-jobs-census) has been recently released. The following five occupations are expected to grow the fastest over the next year:

- Photovoltaic installers (51-66% growth)

- Electricians with specific experience in solar installations (42-55% growth)
- Sales occupations at wholesale trade firms (40-49% growth)
- Sales representatives or estimators at installation firms (39-47% growth)
- Roofers with specific experience in solar installations (36-49% growth)

The range of skill sets that have been identified include electrical and construction skills and experience, customer service skills, and a baseline understanding of solar power.

Given rapidly rising interest in solar energy alternatives, future years may well see worldwide employment soar—possibly as high as 6.3 million in PV by 2030. Projections for individual countries all indicate strong potential for large job creation in coming years and decades. Installations and maintenance of solar PV and solar thermal systems in particular offer tremendous job growth (UNEP/ILO/IOE/ITUC, 2008).

China's employment numbers, for example, are particularly high because the country continues to rely on large numbers of relatively low paid workers. This is in contrast with the fewer higher paid workers found in Western industrialized countries.

Kenya, another example, has one of the largest and most dynamic solar markets in the developing world. In Nairobi, the Kibera Community Youth Program initiated a simple solar PV assembly project, providing young people with employment and engendering considerable interest in emulating the success story in neighbouring countries. In Bangladesh, Grameen Shakti microloans have helped to install more than 100,000 solar home systems in rural communities in a few years, with a goal of 1 million by 2015. Grameen is training local youth and women as certified solar technicians and as repair and maintenance specialists, hoping to create some 100,000 jobs (UNEP/ILO/IOE/ITUC, 2008).

3.3 Drivers of change

Many factors are influencing change in the sector and these are resulting in challenges and opportunities for workforce development. Among the most important ones, are the following drivers: favourable policies, investment environment, technology maturity and scale-up, consumer demand, access to low-cost capital, resource availability, R&D breakthroughs, public acceptance, utility acceptance, supportive infrastructure, globalization, gender empowerment, local and community action, urban planning, building design, transportation planning, land use planning, consumptions patterns, materials use, and energy efficiency.

There are many interconnections among all of these factors. Policies, investments, and consumer demand are among the key factors generally considered to be major drivers. The increase in demand for products and their installations is resulting in a growing sector. However, this sector growth is resulting in a growing need for qualified workforce to accommodate the demands for more solar products and services.

4 Addressing skill shortages

4.1 Shortages

As the industry grows, the need for a skilled workforce grows and the need for specialized training grows. The occupations that are harder to fill are those that require the more specialized training. Shortages are occurring mainly where demand is increasing rapidly and cannot be supplied quickly because substantial training is required. In addition, more emphasis is being placed on creating a system of certifications that more explicitly guarantee the trainees are appropriately qualified, and remain so.

In the solar thermal and PV areas qualified people are needed to do installations. In general there is a growing gap between the demand for installations and the skilled labour to do the work. In the manufacturing sector there is not such a shortage of workers. This is due in part to the fact that most of these manufacturing assembly line jobs are undertaken by general operatives, rather than by specialized workers.

Much solar workforce development activity, both PV and thermal, is focusing now on installation training and commensurate inspections. Part of this has been motivated by problems (i.e., malfunctioning systems) with installed PV and solar thermal systems. In addition to training, various systems of inspection also have

been introduced to assure the design and quality of installations, and in some cases there are requirements for permits that have the same objective. To make sure that these checks and balances are properly in place, building inspectors must also be trained in solar installations in order to be able to properly spot errors in the plans associated with obtaining the permits and/or the faulty installations.

Other areas where problems have been encountered include sales, site assessment and estimation of project costs. These three functions are closely related and involve the early interaction between the installation contractor and the customer. Improperly performed site assessment and/or project cost estimating can have serious financial consequences for the contractor, customer or both. These potential problems can often be avoided through training programs that specifically target marketing and sales personnel, site assessors, licensed contractors, architectural and engineering firms, managers and facilities personnel.

Related to this is the need for people working in all of the installation related areas to understand the safety risks, good design, and aesthetics associated with systems. Not only is it important for people to acquire specialized skills and understanding of these aspects. It also is important that people in related fields such as HVAC, engineering and architecture have adequate quality knowledge of solar technologies.

4.2 Training Opportunities

The resources available for training and education opportunities vary greatly by region and country. Those regions and countries with the greatest market penetration of solar energy technologies have the highest numbers of skilled workers in the solar professions along with well-established educational structures to meet the growing market demands. Examples include Germany and Austria, where a wide range of highly skilled workers from installers and operators to researchers and scientists create a wealth of human resources to strengthen and grow the sector. Also these countries offer well-established training and educational programmes, especially apprenticeship programmes for installers and other highly skilled hands-on professions. For example, Austria has a comprehensive training and education system in place at all levels; solar energy is prominent in classes from secondary school education to university, as well as through other professional courses particularly for the solar thermal sector.

Those countries with emerging solar markets are creating the educational and training structures to train and re-train a growing workforce to meet the demands of the markets. This includes retraining workers in certain “blue collar” professions like plumbers and electricians in the particulars of solar energy technologies.

The least developed countries are unique in that training programmes are being offered more and more to educate local people in the use and installation of solar technologies, especially at the rural level where solar energy is bringing energy to “off-grid” communities. Training and education in solar technologies installation and maintenance are key to any solar rural electrification programme. However, there are still large knowledge gaps to overcome, as well as shortage of highly skilled workers to plan and implement a full spectrum of projects and develop a strong industry.

One example of a country in the early stages of providing specialized training is Uganda. In this country, the demand for in-country specialized training is emerging. Uganda Martyrs University does offer Bachelor of Environmental Design, a Graduate Diploma in Environmental Design, a Master of Environment Design and, most recently, a few short courses in renewable energy. The university is planning to expand its offerings to address the needs. The Faculty of technology at the Makerere University also offers a master degree program in Renewable energy. This program was developed with input from both local and international stakeholders and trains students on the use of renewable energy including appropriate technology such as solar lamps that replace traditional kerosene lamps.

In general, according to training providers, the most notable shifts in curriculum include more specific offerings on safety and related regulations. This is based on the universal demand for high quality products and installations for all of the solar sector activities.

Many training providers rely on partnering with other organizations that are active in policy and/or other areas not traditionally covered in training programs. Providers also rely on their networks of advisers and participation in various conferences and tradeshows to keep up to date with changing workforce needs. Some also license their curriculum to academic institutions and partner with businesses and other non-profits seeking to employ or help in training qualified professionals.

Due to the variations in the sector and differences among regions, even within countries, such as the US where the labour and training resources vary from state to state, it is difficult to make a global assessment of resources and deployment. It is clear though that those countries and regions with ambitious renewable energy targets must include workforce development training and education where stakeholders, including industry, research, education and training institutions and labour organisations participate, in supportive policy frameworks to meet growing market demands.

4.3 Ensuring Effective Programs

Care should be exercised in promoting programs for which there is no market demand. The best approach is to design programs that provide add-on skills to existing trades and professions until market demand reaches the point of justifying specialized programs. Training should be concentrated in areas where there is at least a reasonable prospect that the skills will be used. REN Alliance argue that new credentials should be introduced to keep pace with an expanding and changing market and workforce, but these credentialing schemes, which drive training demand, should be designed according to international guidelines.

One unfortunate outcome of the increasing need for qualified installers is the rise in training organizations that are not adequately qualified themselves. In the US, the US Dept of Energy is trying to address this growing problem through the Solar Instructor Training Network.[1] This program promotes high-quality training in the installation of solar technologies. Nine regional resource and training providers support the professional development of trainers and instructors of solar photovoltaic (PV) and solar heating and cooling (SHC) technologies across the country. The goals of Solar Instructor Training are to accelerate market adoption of solar technologies by ensuring that high-quality installations are standard and to create sustainable jobs within the solar installation industry. The Solar Instructor Training Network was launched in October 2009 to address a critical need for high-quality, local, and accessible training in solar system design, installation, sales, and inspection. Solar Instructor Training is a 5-year effort intended to create a geographic blanket of training opportunities in solar installation across the United States.

In terms of addressing the need for standards across countries, the Institute for Sustainable Power (ISP) has been promoting this important initiative.[2] ISP is a non-profit organization, incorporated in 1996, to coordinate, develop, and maintain international standards for the education and qualification of renewable energy, energy efficiency, and distributed generation providers. Organizations accredited by the ISP Regional Licensees, and individuals certified, attest that they have the skills and resources to deliver high-quality training covering the skills and competency requirements of specific renewable energy, energy efficiency and distributed generation trades. This type of effort clearly needs to be well-recognized and accepted worldwide in order for a true global standard to be developed effectively and used extensively.

5. Recommendations

The demand for a workforce to accommodate the rapid growth in the solar sector is strong. However, more and more attention is being paid to producing highest quality products and services. Of particular concern is the training of installers, and the proper training of those training them. Similarly the professionals tasked with evaluating the work of the installers and other related activities also need to be properly educated for their tasks.

Development of comprehensive universal standards for accrediting/certifying core occupations, in particular for PV and solar thermal installers is needed. These standards need to cover all safety and design factors. In addition, standards need to be in place for certifying the trainers themselves and for properly certifying the people who evaluate the installations.

The need for worldwide certification and for standardization of these certifications also is recognized as an important goal throughout the world. While this is a major consideration for the installers, it is also a

[1] http://www1.eere.energy.gov/solar/instructor_training_network.html
[2] http://www.ispglobal.org/

consideration in the development of solar products. Such certification programs are being considered in different countries and have been initiated on a global scale at some levels. However, comprehensive international standards are yet to be fully developed and put into use.

The need for high quality standards in installation and manufacturing that are applicable across countries is being addressed at some level through various organizations, such as the International Electrotechnical Commission[1] International Organization for Standardization[2] ,and the European Committee for Standardization[3].

At the same time, specific training needs vary considerably from country to country. Training and education programmes should adapt to meet the needs of each country (e.g., Spain has different conditions than Scandinavia). So, while programs need to meet certain standards, differences in climate, culture and other design factors need to be taken into account in the programs.

Educators and the industry should approach training with the same attentiveness. It is up to the industry's leaders to ensure that instruction is based on industry-defined workplace knowledge, skills and attitudes that fully address issues of safety, codes and jurisdictional requirements. It is up to educators to combine in-class and hands-on training and to assure that instructors bring both content and practical experience to the class. Both industry and educators should make sure that training is leading to job availability.

Instituting building directives for use of renewable energy to meet heating/cooling demands will help accelerate the demand for high quality products and services. When directives state that buildings must be outfitted with solar technologies and installations must be done by qualified installers, a change in the labour market will be created and quality will improve. People look to how they can properly qualify themselves and meet the requirements, which in turn drives educators/trainers to offer more programmes in solar areas.

In summary, qualification schemes across countries will help guarantee installations will be of highest quality regardless of where products are manufactured and the installations take place.

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