Approaches to Hands-On PV Training

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Presentation Overview

- Identify approaches for integrating hands-on exercises and assessments into training programs on photovoltaic (PV) systems.

- Discuss examples of different types and levels of activities and assessments, based on target groups, their experience and qualifications, and expectations on the job.

- Define requirements for facilities and equipment, instructor support and laboratory procedures.
The ideal types and levels of exercises and activities for PV training and education programs vary widely, and depend on many factors:

- Type of course or program
  - entry level to advanced, specific topics
- Student expectations and terminal objectives
- Student experience and course prerequisites
- Student to instructor ratios
- Instructor experience
- Institutional support, facilities and funding
PV Industry Sectors and Opportunities

- Research & Development
- Consumers & Owners
- Building Officials & Regulators
- Codes & Standards
- Contractors & Installers
- Policymakers & Government Agencies
- Architects & Engineers
- Product Manufacturers
- Certification & Licensing
- Marketing & Distribution
- Financiers & Investors
- Education & Training
- Insurers & Underwriters
- Project Developers & Integrators
- Energy Suppliers & Electric Utilities

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No one can be effectively trained in a single course or program to competently do everything associated with the solar PV industry.

As the industry develops and matures, specific roles and responsibilities are emerging:
- Sales and marketing
- Project development and management
- Financing and liability
- Design and engineering
- Contracting and installation
- Permitting, inspection and interconnection approvals
- Commissioning, operations and maintenance
The State of PV Training

- Most PV systems training offered today is very basic, introductory level subject matter that is not alone adequate for the expectations and demands of the job.
  - Unless, those students are already adequately trained on electrical systems and their installation requirements.

- Too much focus on immediate job placement from short-term training with insufficient prerequisites.
  - Guarantee for failure

- Most training for young adult learners lacks sufficient fundamentals on electrical power systems, the governing codes and standards, and construction safety.
Most training and education offered today are short courses consistent with continuing education programs for incumbent and experienced professionals with core skill sets.

The best model for young adult learners is to integrate PV systems training into comprehensive degree or certification-track programs, such as electrical apprenticeship or AS programs.

The best programs integrate classroom training with significant on-the-job, supervised and mentored experience – i.e., apprenticeship.
Laboratory Development

Fundamentals and Principles - Demonstrations

Real Installation Practice

Low Cost

High Cost
Define class projects and exercises, assign team members to group projects with designated leaders.

- Optimal groups of 3 to 4 students
- Require learner presentations,

Demonstrations (show and tell) may be suitable for illustrating certain procedures or functions, but lack sufficient opportunities for practice or addressing real problems encountered in the field.

Certain prerequisites should be required for all but basic (entry) level courses, and largely define the appropriate level of hands-on activities.
Skilled Worker Training

- Truly skilled workers develop abilities over many hours and years of relevant job experience.

- Entry programs and short-term training should focus on establishing minimum level knowledge and understanding – not competencies.

- Advanced programs should focus on specific on-the-job tasks.
Advanced Laboratory Exercises

- IEC 61226 – Grid-Connected Systems: Minimum Requirements for System Documentation, Commissioning and Inspection
  - Covers detailed electrical safety and performance measurements
- Teaching fundamental hands-on skills is not required for experienced tradespersons in continuing education courses.
Developed in late 1980s to build on fundamentals and theory of PV – mainly stand-alone applications.

- PV module I-V curves
- Series/parallel and shading experiments
- Electrical loads and characteristics
- Inverter principles and operation
- Battery fundamentals and maintenance
- Charge controller fundamentals and set points
- Site surveys and shading analysis
- System assembly exercises
**Electrical Plan**

**Construction Notes:**

1. Contractor shall specify electrical components and verify appropriate ratings.

2. Conduit trench to training area shall include two 3” conduits and one 1-1/2: conduit (PVC Sch 40).

3. Conduit and conductor oversized for voltage drop and possible future expansion.

4. Conduit above ground shall be Sch 40 rigid galvanized steel.

5. All equipment shall be outdoor rated and rain proof.

6. Add appropriate grounding electrodes and surge protection at main building feeder and local distribution panel.

7. All conductors copper, 75 or 90C.

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**Diagram:**

- 480-Y MSB in Main Building
- 70 A
- 3” conduit: 2/0 AWG (4), 4 AWG (1) – 350 ft
- Install extra 3” & 1-1/2 conduit in trench (empty)
- 200 A Fused Disconnect w/ 70 A Fuse
- 480 V / 208V 3 ph 45 kVA Transformer
  - Dry type, pad mounted
- 2” conduit: 4/0 AWG (4), 4 AWG (1)
- 200 A Fused Disconnect w/ 150 A Fuse
- 120/208 V 3-PhPanel
  - 320 A rated w/ 150 A main breaker
  - Surge protection
- Dashed line indicated co-located equipment at outdoor power distribution center.
  - Equipment to be installed on minimum 8’wide x 7 foot tall wall with covered awning at working height.
- Underground distribution to six (6) local power centers. Use 1-1/2 conduit with #2 AWG (3) and #6 AWG (1) w/ 60 A breakers.
Dashed line indicated co-located equipment at local power distribution centers (6).

Equipment to be installed on minimum 4’ wide x 5 foot tall wall with covered awning at working height.

To be located immediately behind roof mounted PV arrays.

Underground distribution to six (6) local power centers. Use 1-1/2 conduit with #2 AWG (3) and #6 AWG (1) w/ 60 A breakers.
12' x 16' Roof Mockup

6" reinforced concrete pad

16' minimum spacing from 6' high fence to south

6' high chain link, architectural aluminum or equivalent fencing.

Reserved area for permanent structure (32 x 64)

Temporary Storage
(no PV array on Bldg)
(16 x 32)

Communications box

Concrete not required

Local power distribution & PV equipment (4' wide x 5' high wall)

Main feeder, transformer and service disconnects (8' wide x 7' high wall)

16' minimum spacing from 6' high fence to east and west

4' wide walkthrough gate

16' wide roller gate

To main building

1-1/2" distribution conduit (6)
3" main power conduit (2)
1-1/2" communications conduit (1)

1-1/2" distribution conduit (6)
3" main power conduit (2)
1-1/2" communications conduit (1)
A safe PV system is installed according to applicable building codes and standards.

PV installer safety includes considerations for a safe work area, safe use of tools and equipment, safe practices for personnel protection, and awareness of safety hazards and how to avoid them.

The installation of PV systems involves a number of safety hazards, principally electrical and fall hazards.
Following are the standards for which OSHA assessed the highest penalties in fiscal year 2010:

1. Fall protection, construction (29 CFR 1926.501)
2. Electrical, general requirements, construction (29 CFR 1926.403)
4. Control of hazardous energy (lockout/tagout), general industry (29 CFR 1910.147)
5. Machines, general requirements, general industry (29 CFR 1910.212)
6. General duty clause (Section 5(a)(1) of the OSH Act) (this is where they get you on 70E)
7. Excavations, requirements for protective systems, construction (29 CFR 1926.652)
10. Ladders, construction (29 CFR 1926.1053)
The 30-hour Construction Outreach Training Program is intended to provide a variety of training to workers with some safety responsibility.

**30-HOUR MANDATORY COURSE TOPICS**

- Introduction to OSHA - at least Two Hours
  - OSHA Act, General Duty Clause, Employer and Employee Rights and Responsibilities, Whistleblower Rights, Recordkeeping basics
  - Inspections, Citations, and Penalties
  - General Safety and Health Provisions, Competent Person, Subpart C
  - Value of Safety and Health
  - OSHA Website, OSHA 300 number and available resources

- OSHA Focus Four Hazards - at least Five Hours (must cover all four areas - minimum 30 minutes on each)
  - Fall Protection, Subpart M (e.g., floors, platforms, roofs)
  - Electrical, Subpart K (e.g., overhead power lines, power tools and cords, temporary wiring, grounding)
  - Struck by (e.g., falling objects, trucks, cranes, constructing masonry walls)
  - Caught in/between (e.g., trench hazards, unguarded machinery, equipment)

- Personal Protective and Lifesaving Equipment, Subpart E - at least Two Hours

- Health Hazards in Construction (for example, noise, hazard comm. and crystalline silica) - at least Two Hours

- Stairways and Ladders, Subpart X - at least One Hour

**30-HOUR ELECTIVE COURSE TOPICS**

- Choose at least 6 of the following topics - Must add up to at least 12 hours

- Fall Protection and Prevention, Subpart F
- Materials Handling, Storage, Use and Disposal, Subpart H
- Tools - Hand and Power, Subpart I
- Welding and Cutting, Subpart J
- Scaffold, Subpart L
- Cranes, Derrick, Hoists, Elevators, and Conveyors, Subpart N
- Mobile and Nonroad Vehicles, Marine Operations, Rollover Protective Structures and Overhead Protection, and Signs, Signals and Barriers, Subparts O, W, and G
- Excavations, Subpart P
- Concrete and Masonry Construction, Subpart Q
- Steel Erection, Subpart R
- Safety and Health Program
- Confined Space Entry
- Powered Industrial Vehicles
- Ergonomics
Intended to provide entry level construction workers general awareness on recognizing and preventing hazards on a construction site.

Workers must receive additional training on hazards specific to their job.
Unqualified and untrained installers, and substandard and unsafe installation practices are perhaps the biggest threats facing consumer acceptance and market growth of the PV industry.

Better training programs include a mix of classroom exercises, hands-on laboratory practice, and on-the-job mentoring.

Effective models for training and workforce development will identify appropriate linkages between:
- Industry sectors and employers
- Occupational skills and job requirements
- Educational/training requirements and providers
Questions?

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