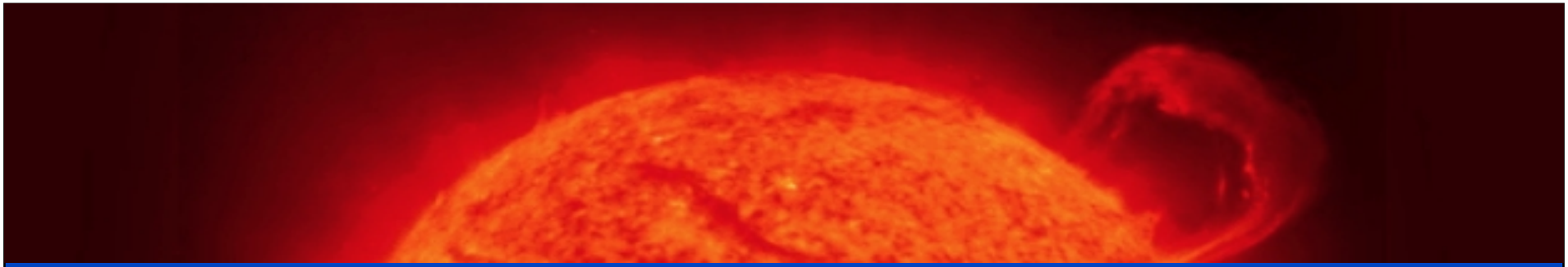


Approaches to Hands-On PV Training

James Dunlop, PE
Jim Dunlop Solar

Presentation Overview

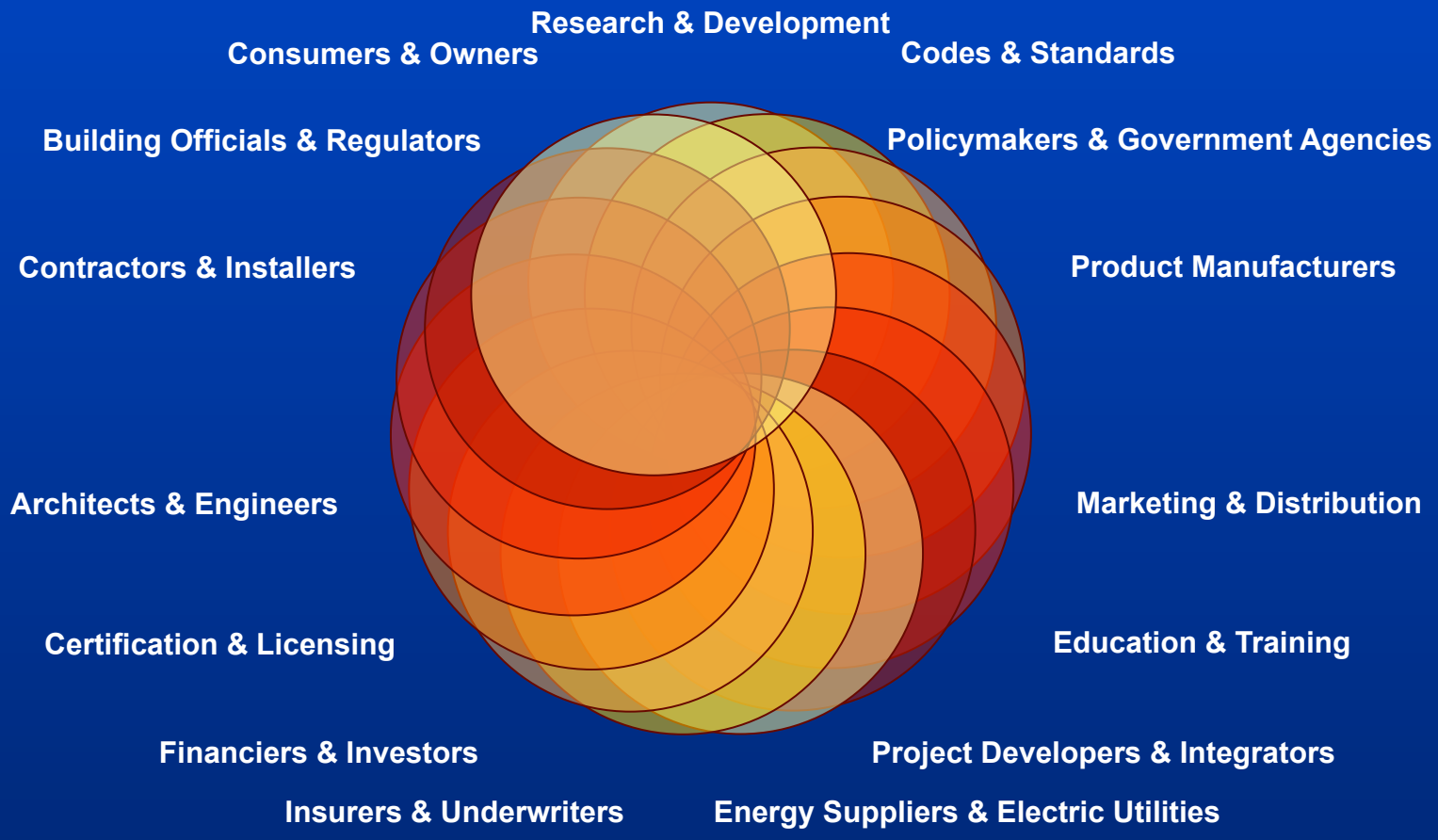
- Identify approaches for integrating hands-on exercises and assessments into training programs on photovoltaic (PV) systems.
- Discuss examples of different types and levels of activities and assessments, based on target groups, their experience and qualifications, and expectations on the job.
- Define requirements for facilities and equipment, instructor support and laboratory procedures.

Presentation Overview

- **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



The Dilemma

- **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.**

Courses vs. Programs

- 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

Laboratory Development

- **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.**

FSEC PV Laboratory Manual

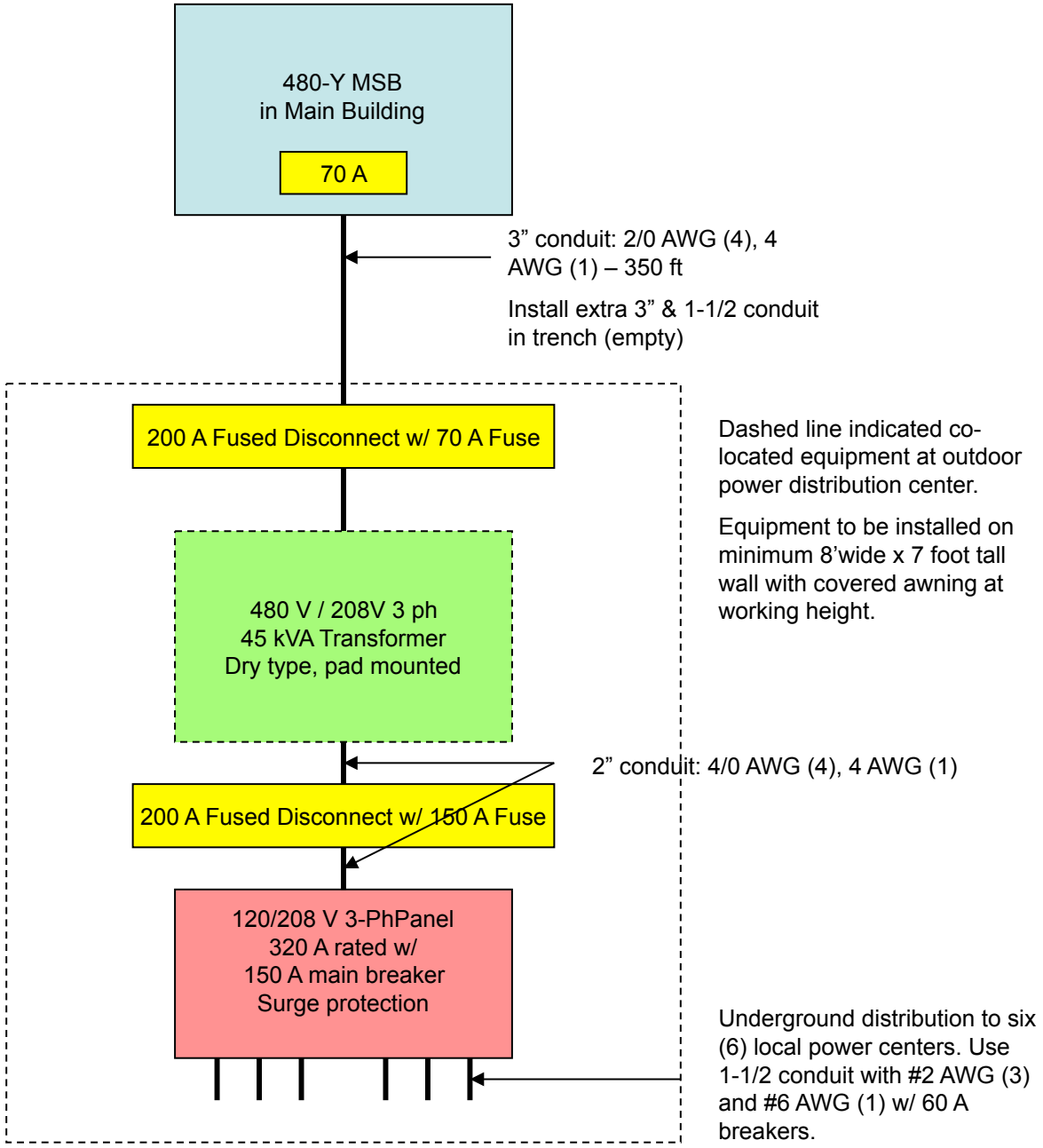
- Developed in late 1980s to build on fundamentals and theory of PV – mainly stand-alone applications.

- 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

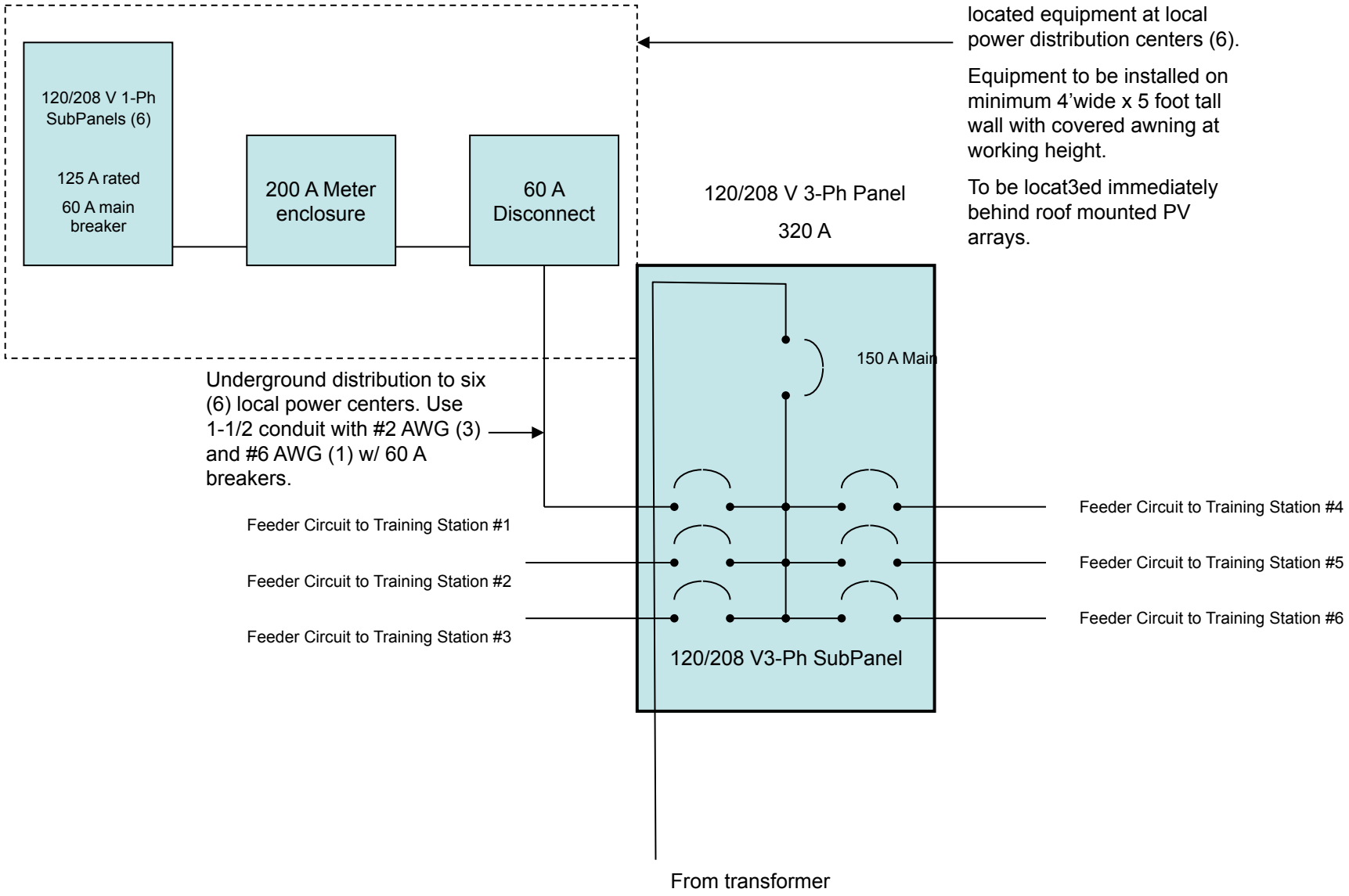
Electrical Plan

Construction Notes:

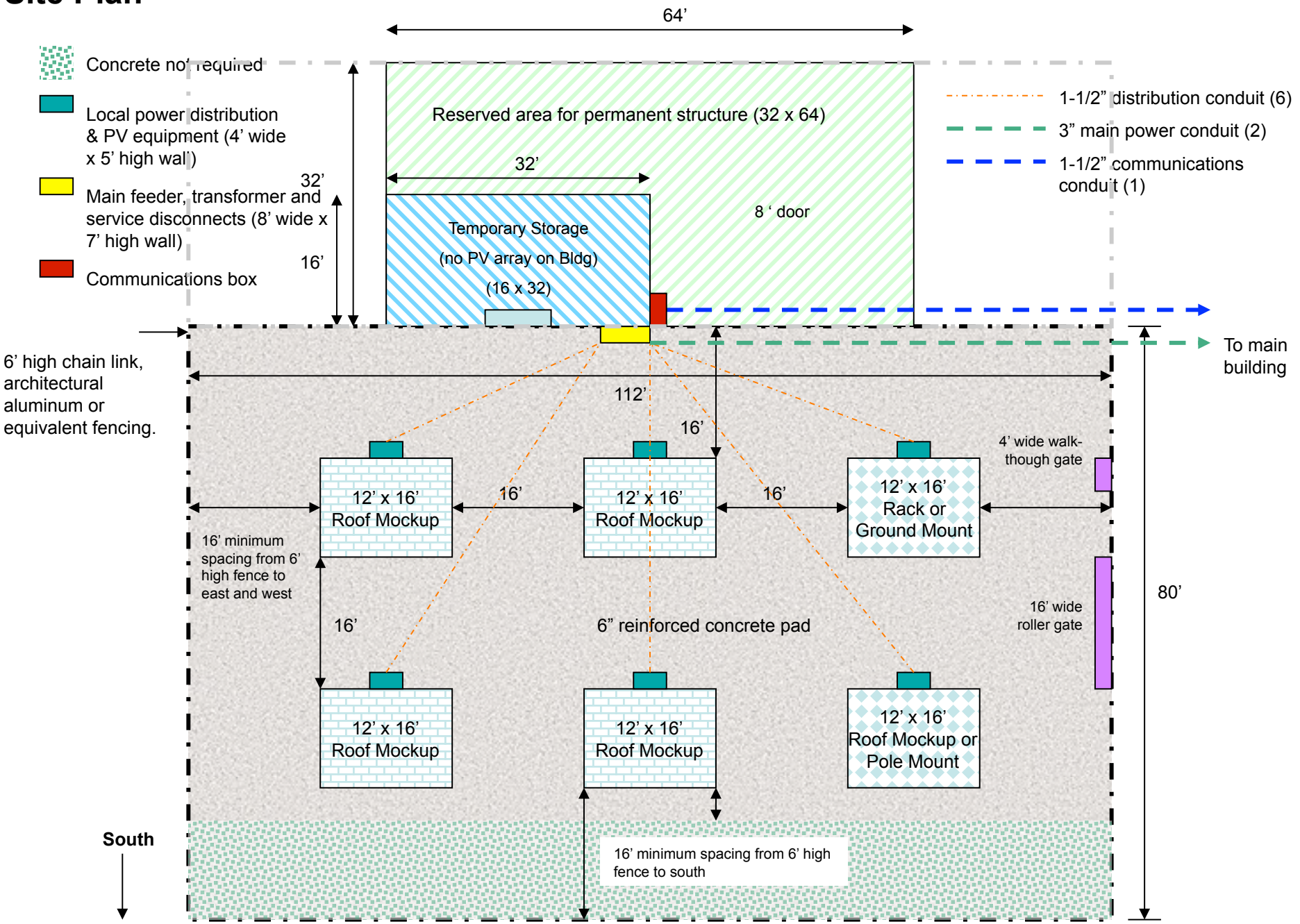
1. Contractor shall specify electrical components and verify appropriate ratings.
2. Conduit trench to training area shall include two 3” conduits and one 1-1/2: conduit (PVC Sch 40).
3. Conduit and conductor oversized for voltage drop and possible future expansion.
4. Conduit above ground shall be Sch 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.



Electrical Plan – Local Power Distribution



Site Plan


64’
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)
Communications box
Reserved area for permanent structure (32 x 64)
32’
32’
16’
Temporary Storage
(no PV array on Bldg)
(16 x 32)
8 ‘ door
1-1/2” distribution conduit (6)
3” main power conduit (2)
1-1/2” communications conduit (1)
To main building
6’ high chain link, architectural aluminum or equivalent fencing.
112’
16’
4’ wide walk-though gate
12’ x 16’ Roof Mockup
16’
12’ x 16’ Roof Mockup
16’
12’ x 16’ Rack or Ground Mount
16’ minimum spacing from 6’ high fence to east and west
16’
6” reinforced concrete pad
16’ wide roller gate
80’
12’ x 16’ Roof Mockup
12’ x 16’ Roof Mockup
12’ x 16’ Roof Mockup or Pole Mount
South
16’ minimum spacing from 6’ high fence to south

Safety Training

- 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.

OSHA's Top 10 Violations

- **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)
3. Safety training and education, construction (29 CFR 1910.21)
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)
8. Lead, general industry (29 CFR 1910.1025)
9. Grain handling facilities (29 CFR 1910.272)
10. Ladders, construction (29 CFR 1926.1053)

OSHA 30-Hour Construction Industry Training Program

- **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
- OSH 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 800 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 com. 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
- Fire Protection and Prevention, Subpart F
- Materials Handling, Storage, Use and Disposal, Subpart H
- Tools - Hand and Power, Subpart I
- Welding and Cutting, Subpart J
- Scaffolds, Subpart L
- Cranes, Derricks, Hoists, Elevators, and Conveyors, Subpart N
- Motor Vehicles, Mechanized Equipment and Marine Operations; Rollover Protective Structures and Overhead Protection; and Signs, Signals and Barricades, 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

OSHA 10-Hour Construction Industry Training Program

- 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.

10-HOUR CONSTRUCTION INDUSTRY REQUIRED COURSE TOPICS

** OSHA subpart references are provided for informational purposes; training should emphasize hazard awareness*

Mandatory – 4 hours	Elective – 2 hours
One Hour **Introduction to OSHA**, including: ■ OSH Act, General Duty Clause, Employer and Employee Rights and Responsibilities, Whistleblower Rights, Recordkeeping basics ■ Inspections, Citations, and Penalties ■ General Safety and Health Provisions, Subpart C ■ Competent Person, Subpart C ■ Value of Safety and Health ■ OSHA Website and available resources ■ OSHA 800 number	**Choose at least two of the following elective topics:** These topics must add up to at least two hours: *- Minimum One-half hour each -* **Materials Handling, Storage, Use and Disposal,** Subpart H **Tools - Hand and Power,** Subpart I **Scaffolds,** Subpart L **Cranes, Derricks, Hoists, Elevators, & Conveyors,** Subpart N **Excavations,** Subpart P **Stairways and Ladders,** Subpart X
Two Hours (minimum 15 minutes on each of four areas) **OSHA Focus Four Hazards** ■ Fall Protection, Subpart M ■ Electrical, Subpart K ■ Struck by (e.g., falling objects, trucks, cranes) ■ Caught in/between (e.g., trench hazards, equipment)	**Optional – 4 hours**
30 Minutes **Personal Protective and Lifesaving Equipment,** Subpart E	**For the remaining four class hours:** Teach any other construction industry hazards or policies and/or expand on the mandatory or elective topics
30 Minutes **Health Hazards in Construction** (e.g., noise, hazard communication and crystalline silica)	

OSHA

Workforce Development Conclusions

- **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

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Questions?

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