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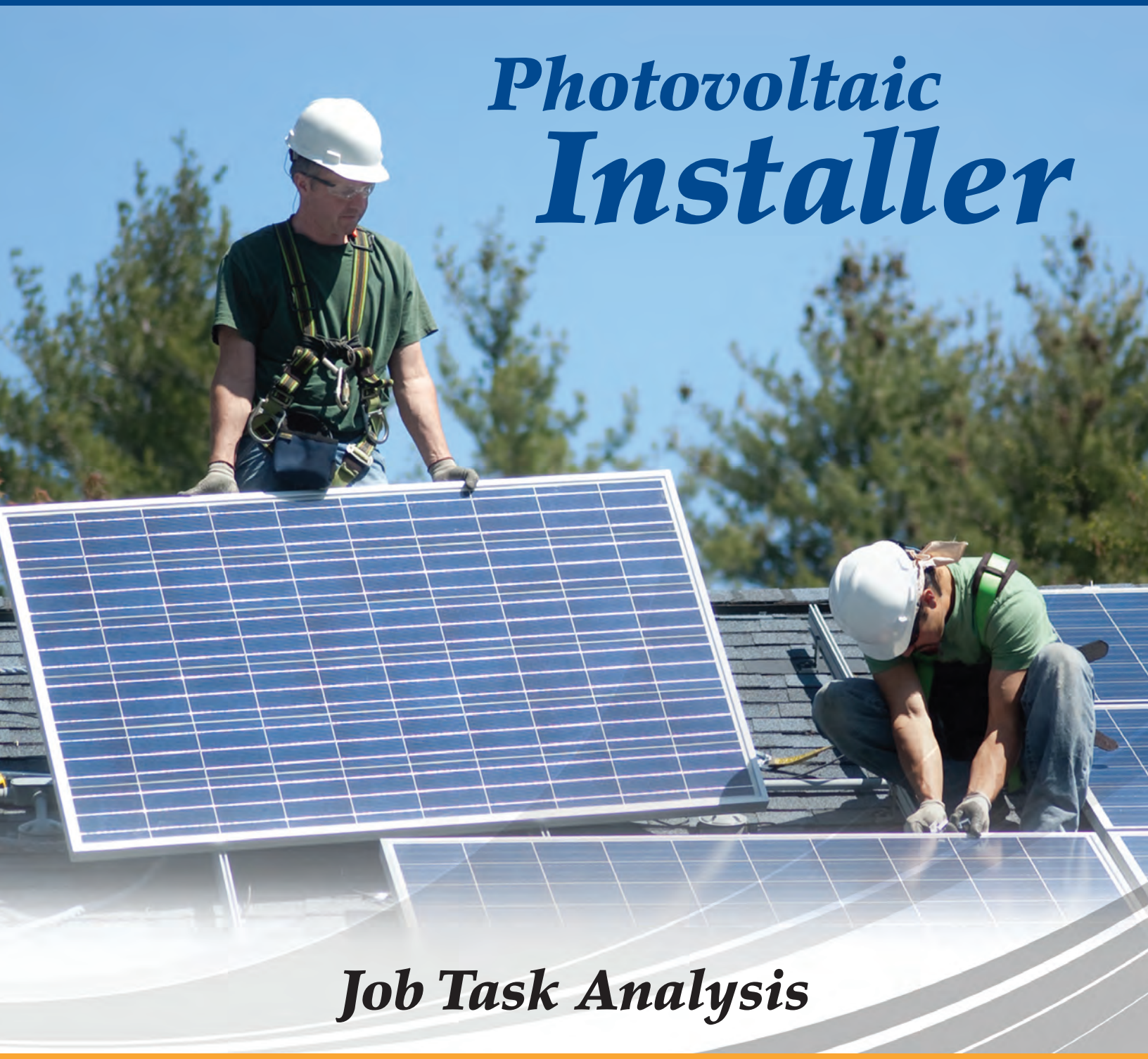

Photovoltaic Installer

Job Task Analysis

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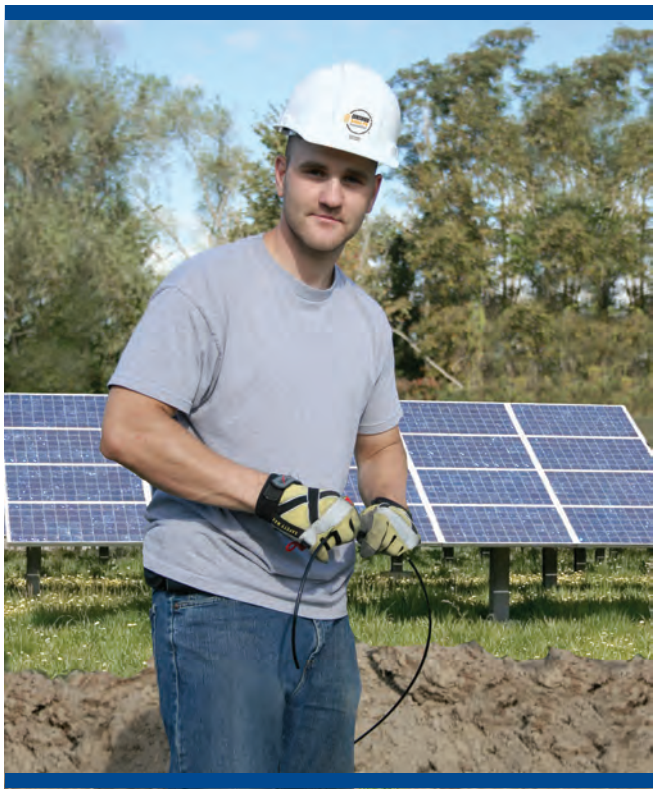
Introduction

This document presents an in-depth Job Task Analysis (JTA) for solar electric professionals who specify, adapt, implement, configure, install, inspect, and maintain photovoltaic (PV) systems, including grid-connected and stand-alone systems, with or without battery storage, that meet the performance and reliability needs of customers in the United States and Canada by incorporating quality craftsmanship and complying with all applicable codes, standards, and safety requirements. This Job Task Analysis was created by a committee of subject matter experts representative of the solar photovoltaic field.



Purpose and Scope

The purpose of this Job Task Analysis is to define a general set of knowledge, skills, and abilities typically required of Solar PV installers who are responsible for the specification, installation, and maintenance of PV systems.

A Job Task Analysis is a foundational document for the development of certification programs, and helps define the requirements for the assessment and credentialing of practitioners. It also helps establish the requirements for accrediting training and educational programs and in developing curricula. These tasks, or modified versions thereof, may be used by states or organizations that wish to develop requirements for education or training to qualify existing or new workers to be involved in the design and sales of Solar PV systems.

This Job Task Analysis is intended to be all-inclusive of the skills and knowledge expected for any qualified PV system installer of any type of PV system, including grid-connected or stand-alone systems, with or without battery storage. In general, these tasks include fundamental site analysis and system design skills, as well as the ability to inspect and maintain all types of PV systems.

Although the concentration is on PV system design and installation, the Job Task Analysis also addresses maintenance, safety, and troubleshooting issues. Electrical codes, safety standards, and accepted industry practice are central to this Job Task Analysis, and are implicit to nearly every task.

NABCEP Certification is not a license to practice, nor does it supersede any licensing requirements. NABCEP Certificants are expected to comply with all applicable federal, state, and local laws and regulations concerning the profession.

The tasks in this JTA will not all be relevant to every PV installation, but rather it is meant as a comprehensive list of all tasks that could be applicable depending on the scope and complexity of the installation. It should also be noted that the tasks under each subsection are not listed in a prioritized order, they are simply categorized within the appropriate topic areas.

Contents

NABCEP PV Installer Examination Specifications

Content Domain

- Designing Systems (30%)
- Managing the Project (17%)
- Installing Electrical Components (22%)
- Installing Mechanical Components (8%)
- Completing System Installation (12%)
- Conducting Maintenance and Troubleshooting Activities (11%)

Job Description:
A Certified Photovoltaic Installer specifies, adapts, implements, configures, installs, inspects, and maintains photovoltaic systems, including grid-connected and stand-alone systems, with or without battery storage, that meet the performance and reliability needs of customers in the United States and Canada, by incorporating quality craftsmanship and complying with all applicable codes, standards, and safety requirements.

NABCEP PV Installer Content Outline

A. Designing Systems

1. Determine Client Needs

- Determine client's energy expectations
- Determine client's financial expectations
- Obtain utility bills
- Perform loads assessment
- Determine critical loads
- Determine client budget
- Confirm system matches client expectation
- Confirm desired location of equipment
- Address aesthetic concerns
- Address legal concerns

2. Perform a Site Survey

- Evaluate roof conditions
- Perform a shading analysis
- Evaluate existing electrical equipment
- Evaluate desired array and equipment locations
- Determine true South
- Locate solar equipment
- Locate conduit paths
- Evaluate roof structure
- Evaluate wind exposure
- Evaluate wall structure
- Evaluate soil conditions
- Determine solar resource
- Measure existing roof tilt and orientation (pitch and azimuth)
- Determine obstructions
- Conduct a site hazard assessment (existing hazards)
- Identify staging/lifting/access locations
- Sketch the site

3. Size the System

- Size the module mounting area
- Evaluate the customer's budget
- Evaluate the energy goals
- Maximize the incentives
- Consider future efficiency upgrades
- Explore utility restrictions
- Determine topography of mounting area
- Arrange modules in mounting area

4. Design Energy Storage Systems

- Determine loads analysis
- Determine storage location
- Determine ventilation requirements
- Identify circuits for critical loads
- Determine access requirements
- Determine existing wiring
- Identify multi-wire branch circuits
- Size batteries to inverter requirements
- Match battery bank to charging sources
- Match battery technology to usage
- Match energy storage system to usage

5. Calculate String Sizes

- Determine highest and lowest design temperature
- Account for module degradation
- Determine module Voc at lowest design temperature
- Determine temperature corrected voltage
- Determine voltage limits of system
- Configure string to match system
- Determine inverter MPPT
- Determine Vpmax at highest design temperature

6. Select System Components

- Match modules to inverters
- Match modules to charge controller
- Match modules to system
- Select combiner boxes
- Determine number of strings
- Determine number and type of inverters
- Determine number and type of charge controllers
- Select module mounting systems
- Ensure component compatibility
- Select string combiners
- Select overcurrent protection
- Select DC disconnect
- Select AC disconnect
- Select grounding method
- Determine maximum number of unprotected strings in parallel
- Select GFP Devices

7. Calculate Wiring and Conduit Size

- Determine ampacity of conductors
- Determine continuous currents
- Determine continuous loads
- Calculate conduit fill
- Determine conditions of use
- Calculate temperature derating
- Calculate conductor derating
- Calculate voltage drop
- Calculate power loss
- Determine distance of run
- Determine conduit type
- Determine wire insulation type
- Determine environmental condition of conduit
- Calculate thermal expansion
- Determine type of grounding conductors
- Determine circuit current
- Calculate conduit size
- Calculate size of grounding conductors

8. Specify Overcurrent Protection

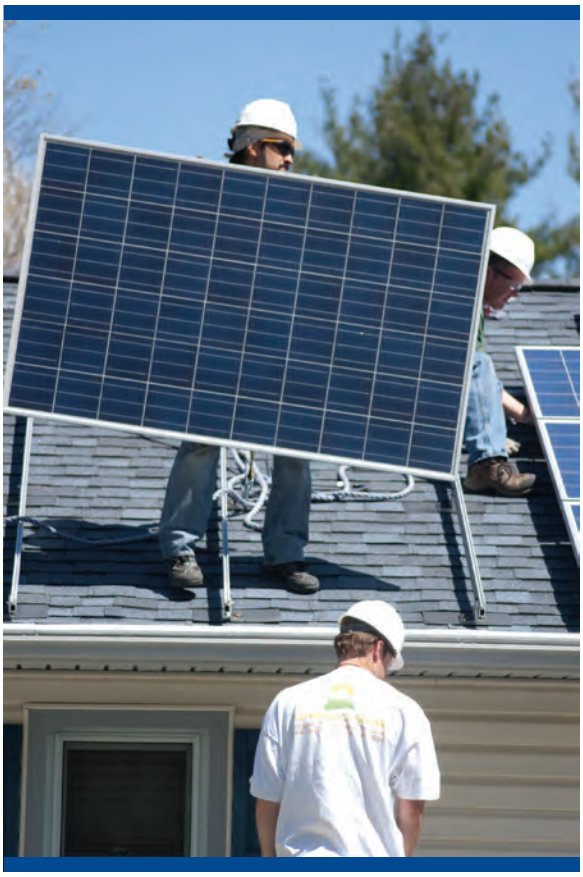
- Calculate circuit currents
- Determine voltage requirements
- Match overcurrent protection to conductor
- Determine characteristics of existing electrical distribution system
- Select overcurrent protection device enclosures
- Determine equipment limits of overcurrent protection
- Determine available fault currents
- Select equipment to match voltage (AC, DC, etc.)
- Determine disconnecting means type
- Determine disconnecting means amperage rating
- Determine disconnecting means location
- Determine temperature rating of OCPD
- Determine terminal temperature limits of OCPD
- Determine environmental conditions
- Determine wire size limitations of OCPD

9. Specify Fasteners

- Determine fastener sizes
- Determine structural characteristics of substrate
- Determine pull-out loads
- Determine pull-out strengths
- Determine wind loading
- Assess environmental conditions
- Determine fastener removal
- Determine type of mounting
- Determine torque values
- Determine force requirements of powder charge
- Determine compatibility of fasteners to system
- Select type of fastener
- Determine necessity and size of pilot hole
- Determine auxiliary materials
- Select weatherproofing materials of building penetrations
- Determine shear loads
- Determine shear strengths
- Determine types of loads
- Specify fastener assembly
- Develop bill of materials

10. Generate Plan Sets

- Clarify design and OEM manuals
- Determine AHJ requirements
- Identify design professional
- Create electrical one- or three-line diagram
- Create a site plan diagram
- Create map to location
- Create equipment layout diagram
- Generate a safety plan
- Assemble manufacturer's data sheets
- Create labeling schedule
- Assemble manufacturer's instructions
- Address structural concerns
- Create structural details
- Determine sheet size
- Generate commissioning forms
- Generate string diagram



B: Managing the Project

1. Conduct Pre-Construction Meetings

- Assemble workforce, including other trades as appropriate
- Determine daily construction goals
- Communicate construction strategy to customer
- Provide customer orientation
- Communicate target pull-off time for crew
- Document safety plan
- Determine community issues
- Determine customer requirements
- Plan weather contingencies
- Resolve scheduling conflicts
- Verify site conditions match design
- Ensure pre-construction commitments by customer are complete

2. Secure Permits and Approvals

- Submit plans to utilities
- Resolve utility conflicts
- Secure written record of approval to interconnect
- Obtain sign-off final building permit
- Coordinate inspections
- Schedule inspections
- Submit plans to building department
- Submit plans to fire department
- Confirm job permits
- Resolve AHJ conflicts
- Determine additional agency permits (e.g., zoning, solar access, HOA, historic district)

3. Manage Project Labor

- Coordinate with subcontractors
- Coordinate with other trades
- Determine order of tasks
- Allocate resources
- Orient contractors to job site conditions
- Resolve disputes
- Supervise project crews
- Track man hours
- Communicate aspects of safety plan
- Conduct toolbox talks
- Confirm licensing compliance
- Confirm insurance compliance

4. Adapt System Design

- Identify potential conflicts in design
- Document changes to proposed design
- Submit modification proposals
- Acquire approvals to change design
- Submit any change orders
- Maintain as-built documentation

5. Manage Project Equipment

- Take delivery of components
- State site equipment
- Schedule machinery
- Ensure equipment operator certification
- Install pedestrian barriers
- Prepare site storage facilities
- Obtain temporary facilities
- Maintain temporary facilities
- Schedule deliveries
- Identify storage location for hazardous materials
- Identify lifting and handling areas
- Perform equipment inspection
- Perform equipment maintenance

6. Implement a Site Specific Safety Plan

- Perform hazard analysis
- Identify job site hazards
- Develop site specific safety plan
- Implement vehicle safety
- Implement ladder safety
- Install site safety barriers

- Implement fall protection plan
- Execute electrical safety
- Select PPE
- Identify access points to site
- Identify site evacuation points
- Post hospital map routes
- Post emergency contact numbers
- Post contingency plan
- Ensure MSDS is onsite

C: Installing Electrical Components

1. Mitigate Electrical Hazards

- Implement the site safety plan
- Implement the lock-out, tag-out procedures
- Determine voltage levels of interconnections
- Maintain clear work area
- Clarify the maximum working voltage
- Select required PPE based on system design (arc flash, shock, burn, voltage, etc.)
- Disconnect all unnecessary live circuits
- Determine working clearances
- Demonstrate situational awareness
- Measure voltage on equipment before proceeding with work
- Measure current on equipment before proceeding with work
- Inspect safety equipment
- Maintain safety equipment
- Inspect test equipment
- Calibrate test equipment
- Inspect hand and power tools
- Maintain hand and power tools

2. Install Grounding Systems

- Install module grounding
- Install inverter grounding
- Make grounding electrode connection
- Install mounting system grounding
- Ground all non-current carrying metal parts
- Install grounding electrode(s)
- Bond metallic raceways
- Install grounding electrode conductor
- Install supplementary ground electrode
- Install system grounds
- Locate underground hazards
- Bond all electrical equipment
- Determine grounding conductor size
- Install DC ground-fault protection
- Apply anti-oxidant material
- Prepare surfaces for electrical connections

3. Install Conduit and Raceways

- Plan conduit routing
- Penetrate building envelope
- Install underground electrical raceways
- Install service entry mast
- Support and secure conduit
- Tighten all fittings
- Select fittings according to application
- Remove sharp edges (deburr)
- Install above ground electrical raceways
- Locate underground utilities
- Create underground trenches
- Backfill underground trenches
- Install conduit bushings
- Make knockouts in raceways
- Mark underground cables
- Mark underground trenches

4. Install Electrical Components

- Select location of DC disconnect
- Mount electrical enclosures
- Install underground electrical components
- Install AC combiner
- Install DC combiner
- Label equipment
- Install PV system disconnects
- Install inverter disconnects

- Install utility required disconnects
- Install meter bases
- Install array wiring transition box
- Install junction boxes in the attic
- Select label materials
- Install inverter

5. Install Circuit Conductors

- Pull conductors
- Label conductors
- Terminate conductors
- Wire the inverter
- Wire modules
- Select the correct wire type, color, and gauge
- Secure conductors
- Set up pull stations
- Measure wires
- Clear the raceway
- Set up the wire installation (tugger, fish tape, rope)
- Test conductor installation
- Splice electrical conductors
- Test DC source circuits
- Test DC currents

6. Install Utility Interconnection

- Coordinate utility shutdowns
- Coordinate with customers and other regarding shutdowns
- Install OCPD
- Install generation metering
- Install disconnects
- Test utility voltage
- Coordinate AHJ inspection
- Verify fill rates
- Terminate conductors
- Test conductor insulation
- Select connection location
- Implement lock-out, tag-out procedures
- Evaluate existing service entrance equipment
- Move existing circuits

7. Install System Instrumentation

- Install communication systems
- Install power and energy metering
- Install environmental sensors
- Install controllers
- Install electrical sensors
- Install inverter interface
- Install power supply
- Establish Ethernet connection
- Program communication systems
- Program instrumentation
- Test system
- Calibrate system
- Install battery temp sensors
- Enroll gateway with offsite monitoring station
- Install data communication cables
- Install outlet for monitoring system
- Program controllers
- Install kiosks and displays

8. Install Battery Components

- Confirm battery bank location
- Install battery enclosure
- Install battery enclosure venting
- Install battery spill containment
- Install seismic tiedown equipment
- Install batteries
- Prepare battery terminals (e.g., clean)
- Install battery interconnection conductors
- Install battery units
- Apply anti-oxidant compounds
- Test each unit before placement (voltage, specific gravity, polarity)
- Terminate fine stranded cables
- Calculate ampacity
- Install charge controller
- Seal conduit entry to battery box
- Install maintenance disconnect
- Label battery units
- Label battery enclosure

- Label battery room
- Establish maintenance schedule
- Test final assembled battery polarity and voltage
- Install safety station

D. Installing Mechanical Components

1. Install Equipment Foundation

- Locate center points of holes
- Excavate to design specifications
- Build concrete forms
- Coordinate foundation inspections
- Identify location of underground utilities
- Add structural reinforcement
- Install wire raceways
- Place concrete to design specifications
- Place anchor hardware
- Install driven posts
- Strip concrete forms
- Backfill excavation
- Place mounting posts
- Install GEC

2. Install Mounting System

- Install tracking apparatus
- Install actuator motors
- Install roof attachments
- Weatherproof penetrations
- Locate ballast for mounting system
- Install supplementary structural supports
- Install seismic and wind loading
- Locate structural roof members
- Determine array attachment locations
- Install structural attachments
- Install module support frame
- Install rack components
- Determine row spacing
- Locate array footprint
- Confirm structural analysis has been performed
- Confirm compatibility with existing roofing system
- Install structural members
- Plumb array structure
- Level array structure
- Apply corrosion protection to cut surfaces

3. Install PV Modules

- Unpack PV modules
- Stage PV modules
- Test PV modules
- Prep PV modules
- Secure module wiring
- Inspect module for physical damage
- Fasten modules to structure
- Torque module fasteners
- Confirm module frame grounding
- Align modules aesthetically
- Determine project workflow

E. Complete System Installation

1. Test the System

- Verify mechanical connection integrity
- Verify system grounding
- Verify electrical connection torque
- Measure insulation resistance
- Verify polarity
- Measure environmental levels
- Measure irradiance levels
- Measure DC voltages (string, output)
- Verify inverter operation
- Measure DC currents
- Calculate expected electrical parameters
- Compare measured values with expected values
- Measure AC system values

- Verify anti-islanding system
- Verify calibration of DAS
- Perform physical inspection
- Verify conduit fitting tightness
- Verify conduit and wiring supports
- Confirm phase rotation
- Verify workmanship
- Test for ground fault

2. Commission the System

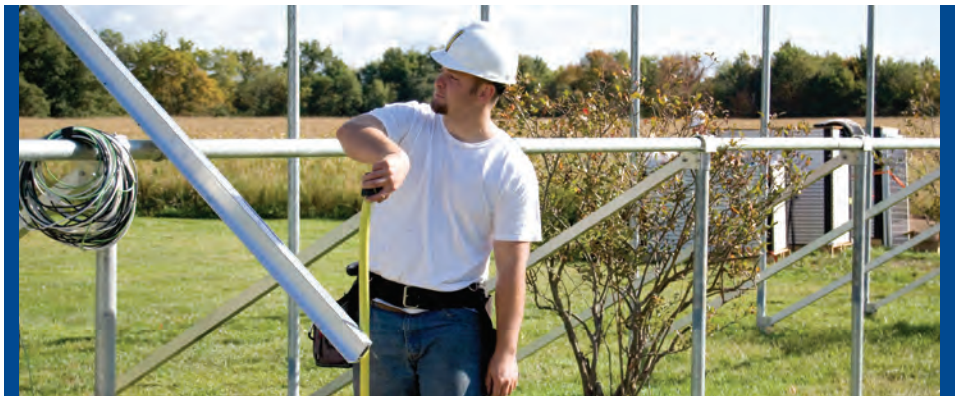
- Verify polarity of energy storage system
- Turn on system
- Initiate startup procedures per manufacturer instructions
- Program variable set points
- Measure all electrical parameters
- Note data and time of system startup
- Compare measured values to expected values
- Monitor startup process
- Record anomalous conditions
- Repair anomalous conditions
- Record environmental conditions
- Record prior values on inverter
- Verify anti-islanding performance
- Photograph meter at startup
- Verify calculation of Total Solar Resource Fraction
- Measure voltage of energy storage system
- Record voltage of energy storage system
- Document design changes
- Verify as-built documentation
- Verify labeling accuracy

3. Complete System Documentation

- Record component serial numbers
- Deliver as-built documents
- File project photographs
- File permits
- Record certificates of inspection
- File inspection forms
- File commissioning forms
- Complete equipment warranty registration
- Complete installation warranty registration
- Complete O&M documentation
- Compile customer operations manual
- File data sheets
- File proof of system test results
- Deliver bill to client

4. Orient Customer to System

- Explain startup and shutdown procedures
- Answer customer questions
- Address customer concerns
- Explain safety procedures to customer
- Explain maintenance procedures
- Train customer on maintenance and operation procedures
- Explain equipment clearance requirements
- Perform customer walk-through
- Provide contact information to customer
- Deliver O&M documentation to customer
- Explain normal operational performance



F. Conducting Maintenance and Troubleshooting Activities

1. Perform Visual Inspection

- Verify equipment grounding
- Inspect module mounting system
- Identify hazards
- Inspect weatherproofing systems
- Inspect for wiring damage
- Inspect module integrity
- Check inverter status
- Inspect electrical equipment
- Inspect for working clearances
- Identify damage due to corrosion
- Identify array shading
- Identify array soiling
- Inspect cells for discoloration
- Verify grounding system integrity
- Identify electrical connections damage due to overheating
- Confirm equipment serial numbers
- Inspect module backskin
- Check conduit fitting tightness
- Look for unsupported wiring
- Identify damage to module glazing
- Inspect for evidence of animals
- Identify vegetation growth
- Identify water ponding
- Identify ice damage
- Document findings
- Identify mismatched equipment

2. Verify System Operation

- Interview customer
- Document customer's concerns
- Compare historical kWh performance against expected kWh performance
- Note inter-annual weather variability
- Measure system electrical parameters
- Document as-found electrical parameters
- Calculate expected electrical parameters
- Compare expected parameters with as-found parameters
- Note anomalous conditions
- Test system electrical equipment operations
- Recommend corrective actions
- Verify source circuits are connected
- Measure equipment temperatures
- Measure terminal temperatures
- Verify operation of battery venting systems
- Verify battery auxiliary systems

3. Perform Corrective Actions

- Clean arrays
- Replace defective modules
- Service ventilation systems
- Clean batteries
- Check equipment variable set points
- Recalibrate equipment variable set points
- Wipe down power conditioning equipment
- Clean heat sinks
- Schedule manufacturer onsite service call
- Perform scheduled maintenance
- Replace frayed wires
- Replace blown fuses
- Replace faulty components
- Locate ground faults
- Repair ground faults
- Trim vegetation
- Clear blocked drainages
- Seal compromised weatherproofing systems
- Mitigate negative local conditions
- Perform battery maintenance
- Perform controlled overcharge
- Locate line to line faults
- Repair line to line faults
- Clean system labeling
- Replace system labeling
- Document corrective actions

4. Verify Effectiveness of Corrective Actions

- Retest electrical parameters
- Retest system operations
- Retest environmental conditions
- Retest weatherproofing system
- Compare pre-maintenance values to post-maintenance values
- Re-orient customer to system

Knowledge

The list below outlines a wide variety of subjects that a Certified PV Installer must have knowledge of.

- Solar resources
- Restrictive covenants
- Expected system production
- Energy vs. power
- Incentive rules
- Incentive programs
- Incentive requirements
- PV fundamentals
- Utility requirements
- Municipal requirements
- NEC/CEC
- Local geographic climatic conditions
- Basic roofing methods and materials
- Roofing systems
- Roof construction
- Roofing techniques
- Roof warranty
- Roofing knowledge
- Roof safety
- Basic construction practices
- Basic building construction
- Construction knowledge
- Calculate magnetic declination
- Basic energy calculations
- Electrical calculations
- Algebra
- Geometry and Trigonometry
- Formulas (voltage drop, etc.)
- Understanding of how to identify structural supports
- Identify electrical hazards
- Inverter characteristics
- Module characteristics (AC, DC, etc.)
- Available technology
- Power tracking
- DC to DC conversion technology
- Utility rate structures
- Module mounting systems
- Interrow shading
- String sizes
- Limits on interconnection size
- State specialty codes
- Financial analysis
- Ergonomics
- Shading
- OSHA
- Structural limits to mounting systems
- Chemistry
- Ventilation methods
- Foundation requirements
- Hazardous materials handling
- Fly-wheels
- AC distribution systems
- Batteries
- Ultra-caps
- Capacitors

Knowledge continued...

- Charging sources
- Charging equipment
- Electricity (e.g., power vs. energy)
- Safety equipment (e.g., eyewash station, fire extinguisher, chemical neutralizer) mitigation factors
- Weather data
- Temperature coefficients of modules
- Module electrical characteristics
- Module thermal characteristics
- Manufacturer's requirements
- Environmental conditions for equipment
- Equipment characteristics
- Equipment locations
- Wiring methodology
- Electrical equipment
- Conductor properties
- Conduit properties
- Local codes, regulations, and requirements
- Materials compatibility
- Environmental conditions
- Conduit installation practices
- Existing electrical distribution and grounding systems
- Costs associated with materials and labor
- Inspector's expectations
- Service requirements
- Equipment costs
- Equipment availability
- Metal compatibility
- Dissimilar metals
- Metallurgy
- Metal properties
- Building codes
- Galling
- Manufacturer's instructions
- Installation methods
- Torque values
- Power tool practices
- Structural codes
- Specialty tools
- Folding techniques
- Electrical drawing symbols
- Local AHJ preferences
- Wiring techniques
- Safety plan
- Timetables
- Chain of command
- Plan set
- Flow of project
- Site access
- Heavy equipment requirements
- Personnel capabilities
- Zoning requirements
- Local requirements
- Electrical codes
- Permit submittal requirements
- Fee schedule
- Inter-agency requirements
- Contractor's safety plans
- Crew strengths and weaknesses
- Insurance requirements
- Licensing requirements
- Labor codes
- Site plans
- Electrical plans
- Design of system
- Common design conflicts
- Electrical best practices
- Actual site conditions
- Fire and access codes
- Customer requests
- Job requirements
- Site requirements
- Customer requirements
- Capacities of machinery
- ADA
- WHMIS
- Weights and measures of materials

Knowledge continued...

- Local worker safety requirements
- First aid procedures
- Ladder safety
- Fall protection equipment
- Harness self-rescue equipment
- CPR
- Lifting equipment
- Vehicle hand signals
- Crane signals
- Journeyman electrical knowledge
- Electrical test equipment
- NFPA 70E
- Local utility policies
- PV Installer responsibilities as they pertain to hazards
- Soil conditions
- Various grounding procedures
- Soil resistance
- Underground hazards
- Electrical and grounding materials
- Electrical and material compatibility
- Aluminum anodizing oxidation clear-coating

- Conductor ampacities
- Ground-fault protection systems
- Lightening protection systems
- Utility contacts
- Underground locating service
- Material selection
- Local AHJ labeling requirements
- Identification of utility owned equipment
- Substrate materials
- Fasteners
- Working clearances
- Inverter locations
- Mounting needs
- Equipment mounting needs
- Seismic requirements
- Terminal torque specs
- Electrical splicing methods
- Utility contact information
- Utility interconnection requirements
- OEM Instructions
- Limitations of existing service entrance equipment
- Available fault current
- Connection methods
- Panel box wiring techniques
- Liability and legal issues
- Local area networks
- IT knowledge
- Energy metering
- Proper locations for sensors
- Plenum rating
- Manufacturer's torque settings
- Battery manufacturer's instructions
- Venting requirements
- MSDS
- Materials handling
- Electrical test procedures
- Carbon monoxide poisoning
- Air exchange calculations

Knowledge continued...

- Concrete
- Heavy equipment operations
- Manufacturer specs
- Design specs
- Local conditions
- Wood density
- Structural member density
- Laser alignment
- Safe handling procedures
- OEM commissioning process
- PV performance characteristics
- Expected system response
- Expected performance values
- Electrical theory
- Intermediate mathematics
- System plans
- Typical system performance
- Effects of environment on PV systems
- Test equipment operation
- Power quality
- Expected system performance
- Jurisdictional requirements
- Customer expectations
- Normal operation of system
- Abnormal operational conditions
- Environmental effects on system performance
- Operational procedures
- Safety concerns
- Equipment clearances
- System layout
- Array installation techniques
- Materials properties
- Grounding techniques
- Electrical knowledge
- Equipment manuals
- Electrical safety
- Normal PV system operation
- Typical problems with PV systems
- Historical environmental conditions
- Safety knowledge
- Expected performance characteristics
- Warranty procedures
- Original installer or designer
- Historical manufacturer model flaws
- Common installation practices
- Common design practices
- Manufacturer technical notifications
- Hospital routes
- Pre-maintenance values
- Post-maintenance values
- Corrective actions taken on site

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