



# NABCEP<sup>®</sup>

---

## Photovoltaic Specialists: Job Task Analysis

Photovoltaic Design, Photovoltaic Installer,  
Photovoltaic Commissioning & Maintenance

September 2017



# Introduction

This document presents a comprehensive Job Task Analysis (JTA) for PV Specialists who perform decision making roles with respect to the design, installation and commissioning & maintenance of Photovoltaic (PV) systems. NABCEP Specialist Credentials all relate to PV installation. The PV Design Specialist, PV Installer Specialist and the PV Commissioning and Maintenance Specialist Certifications each focus on one domain from the NABCEP PV Installation Professional classification system. The Exams were formulated by Subject Matter Experts with input from a wide range of individuals working in the industry.

## Who Are NABCEP PV Specialists?



### PV Design Specialist (PVDS)

Experts at configuring the electrical design of a project. In assessing the project site, PVDS will be able to design both the mechanical and electrical design components with confidence, accuracy and safety.



### PV Installer Specialist (PVIS)

Highly competent with all aspects of PV installation including DC and AC PV system conductors and grounding and bonding systems. As with all NABCEP credentials, safety standards and plans are of critical importance.



### PV Commissioning and Maintenance Specialist (PVCMS)

NABCEP PVCMS Specialists combine the skill sets of operations, maintenance and commissioning tasks into one job specialty. Exceptional application of verification protocols and preventive and corrective maintenance operations are key to this Certification.

### Scope of the JTAs

NABCEP Certified PV Specialists work in a variety of responsible roles on PV installation jobs. Varying sizes and complexities of installations calls for a wide range of duties required of any PV Installation Professional.

The NABCEP Specialist Exams are designed to narrow the scope of duties while elevating the competency of the specified technology.

### Task Steps & Knowledge

Individuals who achieve a NABCEP Specialist Certification will be familiar with and capable of executing all the tasks listed in the specific examination content outline below. These tasks may not be performed on every project but they are an important part of a body of knowledge.

# Content Domains and Examination Specifications

## PV Design Specialist

Description	Percent of Test
Review customer expectations.....	12%
Review project criteria.....	12%
Assess project site .....	15%
Configure mechanical design.....	13%
Configure electrical design.....	17%
Configure system monitoring, control, and communications design .....	7%
Prepare project documentation .....	8%
Secure permits and approvals .....	8%
Adapt system design .....	8%

## PV Installer Specialist

Description	Percent of Test
Develop safety plan.....	8%
Safeguard against hazards.....	10%
Install raceways.....	7%
Install electrical equipment .....	8%
Install DC PV system conductors .....	8%
Install AC PV system conductors .....	8%
Install grounding & bonding.....	10%
Complete utility interconnection point.....	8%
Install system monitoring, control, and communication hardware .....	3%
Install battery equipment .....	7%
Install ground-mounted structure .....	5%
Install building-mounted system.....	8%
Install PV modules .....	8%

## PV Commissioning & Maintenance Specialist

Description	Percent of Test
Review or develop commissioning protocol.....	10%
Complete visual and mechanical inspection.....	12%
Conduct mechanical tests.....	8%
Conduct electrical tests .....	15%
Verify system operation .....	10%
Confirm project completion.....	8%
Orient end user to system .....	8%
Verify system operation and performance.....	8%
Perform preventive maintenance .....	10%
Perform corrective maintenance.....	10%



## CATEGORIES PER PV SPECIALTY EXAM

### PV Design Specialist (PVDS)

#### PVDS Task 1: Review Customer Expectations

**Knowledge of:**

- a. Equipment location
- b. Aesthetic concerns
- c. Electric loads assessment (e.g., new construction, multi-modal and stand-alone systems)
- d. System functionality and performance requirements
- e. Value engineering

#### PVDS Task 2: Review Project Criteria

**Knowledge of:**

- a. Authorities having jurisdiction criteria (e.g., codes, standards, covenants, and regulations)
- b. Electric service provider criteria (e.g., utilities, co-ops, third-party providers)
- c. Construction plan sets and project specification documents

#### PVDS Task 3: Assess Project Site

**Knowledge of:**

- |   |  |
|---|--|
| a. Characteristics of appropriate array locations     | k. Construction site hazards   |
| b. Characteristics of viable roof surfaces            | l. Characteristics of appropriate staging/lifting/<br>access locations |
| c. Live and dead load characteristics of PV arrays    | m. Shading analysis tools and techniques                               |
| d. Common roof structural design                      | n. Azimuth measurement tools   |
| e. Drilling and trenching equipment capabilities      | o. Magnetic declination  |
| f. Characteristics of appropriate equipment locations | p. Slope tools and techniques  |
| g. Types of electrical services                       | q. Building use and dimensions   |
| h. Point of interconnection                           | r. Effects of wind exposure  |
| i. Raceway installation parameters                    | s. Required site information documentation                             |
| j. Effect of obstructions                             |  |

#### PVDS Task 4: Configure Mechanical Design

**Knowledge of:**

- |  |   |
|--|---|
| a. PV system performance simulation software   | g. Existing and allowable loads<br>(e.g., snow load, seismic)           |
| b. Basic algebra, geometry, and trigonometry<br>calculations (e.g., area, slope, inter-row shading,<br>withdrawal loads) | h. Design principles of ground mount foundations                        |
| c. Characteristics of racking systems  | i. Effect of PV module tilt and orientation                             |
| d. Fastener selection criteria (e.g., types, sizes)  | j. Characteristics of PV module technologies                            |
| e. Structure attachment criteria (e.g., spacing,<br>quantity, type)  | k. Methods for equipment racking and/or installation                    |
| f. Waterproofing and flashing methods and materials  | l. Criteria for placement of energy storage systems                     |
|  | m. Pathways and setbacks (e.g., walkways,<br>clearances, accessibility) |

## PV DESIGN SPECIALIST (PVDS)

### PVDS Task 5: Configure Electrical Design

#### Knowledge of:

- a. Inverter selection criteria (e.g., types of inverters, DC to AC ratio)
- b. String size calculations and layout
- c. DC circuit sizing formulas (e.g., PV source and output circuits, battery cables)
- d. AC circuit sizing formulas (e.g., inverter output circuit, feeders)
- e. Module level power electronics (MLPE)
- f. Voltage drop calculations
- g. Methods of interconnection (e.g., supply-side connection, load-side connection)
- h. Conductor properties and types
- i. Raceway selection criteria and calculations
- j. Raceway installation methods
- k. Source circuit combining methods (e.g., combiner boxes, wire harnesses)
- l. Overcurrent protection selection criteria
- m. Electrical enclosure selection criteria
- n. Panelboard selection criteria
- o. Disconnect selection criteria
- p. Grounding system criteria and components
- q. Rapid shutdown equipment and methods
- r. Arc-fault protection equipment and methods
- s. Characteristics of battery technologies
- t. Characteristics of charge controllers
- u. Characteristics and components of AC coupled systems
- v. Energy storage system sizing and performance calculations
- w. Power requirements of auxiliary systems (including backup power)

# PV Installer Specialist Examination (PVIS)

## PVIS Task 1: Develop Safety Plan

- a. OSHA requirements (e.g., fall protection, competent/qualified person, reporting of incidents)
- b. NFPA 70E (National Fire Protection Association — Standard for Electrical Safety in the Workplace)
- c. Personal protective equipment (PPE) (e.g., specific equipment required for project, maintenance of PPE)
- d. Material safety data sheet (MSDS)
- e. Emergency response resources and protocols
- f. Weather event response actions
- g. Specific equipment and training required for site
- h. Elements of an effective safety meeting

## PVIS Task 2: Safeguard Against Hazards

### Knowledge of:

- a. NFPA 70E (National Fire Protection Association — Standard for Electrical Safety in the Workplace)
- b. OSHA CFR 29 1926 safety standards
- c. Proper care and use of safety equipment (e.g., life cycle, defects, storage)
- d. Proper care and use of test equipment (e.g., life cycle, defects, storage)
- e. Proper care and use of power tools (e.g., life cycle, defects, storage)
- f. Safe work practices

### Skill in:

*\* Effectively implementing the site specific safety plan*

## PVIS Task 3: Install Raceways

### Knowledge of:

- a. NFPA 70 (NEC) articles for use, installation, and construction specifications for raceways and associated fittings
- b. Raceway manufacturer specifications and installation requirements
- c. Proper raceway selection and sizing
- d. Proper installation and labeling of raceways per NFPA 70/AHJ requirements (e.g., expansion joints, physical protection)
- e. Neat and workmanlike manner of installation of raceways
- f. Plan sets and schematics

### Skill in:

*\* Confirming raceway routing per plans and client input*

## PV INSTALLER SPECIALIST (PVIS)

### PVIS Task 4: Install Electrical Equipment

#### Knowledge of:

- a. NFPA 70 (NEC) articles for use, installation, and construction specifications for equipment and associated fittings
- b. Equipment manufacturer specifications and installation requirements
- c. Neat and workmanlike manner of installation of electrical equipment
- d. Proper installation and labeling of equipment per NFPA 70 requirements
- e. Plan sets and schematics

#### Skill in:

- \* *Confirming equipment suitability and placement per plans and client input*
- \* *Providing and maintaining access and working space around all electrical equipment*
- \* *Interpreting construction plans (e.g, electrical plans, schematics, line diagrams)*

### PVIS Task 5: Install DC P System Conductors

#### Knowledge of:

- a. NFPA 70 (NEC) articles for use, installation, and construction specifications for DC conductors
- b. NFPA 70E (National Fire Protection Association—Standard for Electrical Safety in the Workplace)
- c. Equipment manufacturer specifications and installation requirements
- d. Appropriate conductor installation and pulling practices
- e. Wire management in a neat and workmanlike manner
- f. Termination and connection per manufacturer specifications

#### Skill in:

- \* *Conducting field verification of proper conductor identification, size, color, type, and rating*
- \* *Properly identifying and labeling DC conductors per plan set and NFPA 70 requirements*
- \* *Conducting string sizing and string configuration per plans and manufacturer specifications*

### PVIS Task 6: Install AC PV System Conductors

#### Knowledge of:

- a. NFPA 70 (NEC) articles for use, installation, and construction specifications for AC conductors
- b. NFPA 70E (National Fire Protection Association—Standard for Electrical Safety in the Workplace)
- c. Conductor manufacturer specifications and installation requirements
- d. Appropriate conductor installation and pulling practices
- e. Wire management in a neat and workmanlike manner
- f. Termination and connection per manufacturer specifications

#### Skill in:

- \* *Conducting field verification of proper conductor identification, size, color, type, and rating*
- \* *Properly identifying and labeling AC conductors per plan set and NFPA 70 requirements*

## PV INSTALLER SPECIALIST (PVIS)

### PVIS Task 7: Install Grounding and Bonding Systems

#### Knowledge of:

- a. NFPA 70 (NEC) articles for use, installation, and construction specifications for grounding and bonding
- b. Proper installation of bonding and bonding jumpers
- c. Grounding systems and certifications (e.g., UL 2703, integrated bonding)

#### Skill in:

- \* *Conducting field verification of existing grounding electrode systems*
- \* *Installing proper system grounding per NFPA 70 and manufacturer specifications (grounding electrode conductor [GEC])*
- \* *Installing proper equipment grounding per NFPA 70 and manufacturer specifications (equipment grounding conductor [EGC])*

### PVIS Task 8: Complete Utility Interconnection Point

#### Knowledge of:

- a. NFPA 70 (NEC) articles for use, installation, and construction specifications for utility interconnection
- b. OSHA safety standards
- c. NFPA 70E (National Fire Protection Association—Standard for Electrical Safety in the Workplace)
- d. Calculation and verification of OCPD overcurrent protection device (OCPD) and disconnecting means
- e. Effective and efficient communication regarding shutdown and inspection processes
- f. Proper termination of conductors per manufacturer specifications
- g. Local electric service provider requirements for interconnection
- h. Methods of interconnection

#### Skill in:

- \* *Effectively implementing the site-specific safety plan*

### PVIS Task 9: Install System Monitoring, Control, and Communication Hardware

#### Knowledge of:

- a. NFPA 70 (NEC) articles for use, installation, and construction specifications
- b. Cable manufacturer specifications and installation requirements
- c. Monitoring equipment manufacturer specifications and installation requirements
- d. Neat and workmanlike installation of monitoring equipment
- e. Types and methods of data communication hardware
- f. Manufacturer specifications and approved plan sets
- g. Termination and connection per manufacturer specifications

#### Skill in:

- \* *Confirming monitoring equipment placement per plans and with client*
- \* *Conducting field verification of final system configuration*
- \* *Conducting field verification of proper cable identification, size, type, and rating*
- \* *Installing equipment per manufacturer specifications and approved plan sets*
- \* *Preparing monitoring system for commissioning*



## PV INSTALLER SPECIALIST (PVIS)

### PVIS Task 10: Install Battery Equipment

#### Knowledge of:

- a. NFPA 70 (NEC) articles for use, installation, and construction specifications for batteries
- b. OSHA safety standards
- c. NFPA 70E (National Fire Protection Association—Standard for Electrical Safety in the Workplace)
- d. Proper installation of batteries and battery equipment (e.g., labeling, spill kits, enclosure, ventilation)
- e. Neat and workmanlike manner of installation of battery equipment
- f. Proper conductor installation, routing, identification, size, color, type, and rating
- g. Proper battery handling, storage, future maintenance, and installation techniques

#### Skill in:

- \* *Implementing the site-specific safety plan*
- \* *Confirming battery equipment placement per plans and client input*
- \* *Installing batteries and battery-related equipment per manufacturer specifications*
- \* *Conducting field verification of proper conductor identification, size, color, type, and rating*

### PVIS Task 11: Install Ground-Mounted Structure

#### Knowledge of:

- a. NFPA 70 (NEC)
- b. Authorities having jurisdiction criteria (e.g., codes, standards, zoning, covenants, regulations)
- c. OSHA safety standards
- d. Ground-mounted structure manufacturer specifications and installation requirements
- e. Module manufacturer mounting specifications and installation requirements
- f. Foundation and structural elements (e.g., geotechnical requirements)
- g. Construction and assembly of PV structure and racking
- h. Neat and workmanlike manner of installation
- i. Coordination of foundation, trench, and pad inspections
- j. Location of underground utilities (e.g., call ahead, underground locator services)
- k. Environmental impact (e.g., protected species, water management)
- l. Site protection and restoration (e.g., straw and seed)
- m. Earth moving equipment

#### Skill in:

- \* *Managing excavation to design specifications (e.g., trenching, piers, foundations)*

## PV INSTALLER SPECIALIST (PVIS)

### PVIS Task 12: Install Building-Mounted Structure

#### Knowledge of:

- |  |  |
|--|--|
| a. Authorities having jurisdiction criteria (e.g., codes, standards, zoning, covenants, regulations) | f. Mounting surface and structure protection and restoration                         |
| b. OSHA safety standards (fall protection, hoisting, scaffolding)                                    | g. Array layouts per location (e.g., inter-row shading, electrical efficiency)       |
| c. Racking manufacturer specifications and installation requirements                                 | h. Neat and workmanlike manner of installation                                       |
| d. Roofing systems manufacturer specifications, warranty, and installation requirements              | i. Types of roofing system construction  |
| e. Mounting surface compositions (e.g., tile, composite, membrane, metal)                            | j. Lightning protection systems  |
|  | k. Staging materials and equipment (e.g., roof or other structure loading, security) |
|  | l. Waterproofing building penetrations   |

#### Skill in:

- \* *Effectively implement the site-specific safety plan*
- \* *Interpreting and applying approved design (e.g., engineered drawings, manufacturer specifications)*
- \* *Installing points of attachment to roof manufacturer requirements*

### PVIS Task 13: Install PV Modules

#### Knowledge of:

- |  |  |
|--|--|
| a. NFPA 70E (National Fire Protection Association—Standard for Electrical Safety in the Workplace) | f. Proper wire management methods and materials                              |
| b. OSHA safety standards (e.g., fall protection, ladder use, lifting)                              | g. Termination and connection per manufacturer specifications                |
| c. Neat and workmanlike manner of installation (e.g., coplanar, square)                            | h. Grounding and bonding (e.g., integrated grounding, bonding washers, lugs) |
| d. Manufacturer specifications for installation of modules   | i. Regional considerations (e.g., animal guarding, ice and snow, wind)       |
| e. Proper module handling and preparation  |  |

#### Skill in:

- \* *Effectively implementing the site-specific safety plan*
- \* *Conducting field verification of equipment selection (e.g., nameplate, racking compatibility)*

# NABCEP PV Commissioning & Maintenance Specialist (PVCMS)

## PVCMS Task 1: Review or Develop Commissioning Protocol

### Knowledge of:

- a. Applicable standards (e.g., manufacturer recommendations, building system, IEC 62446-1, performance testing)
- b. NFPA 70E (National Fire Protection Association—Standard for Electrical Safety in the Workplace)
- c. Contract requirements and intent of design
- d. Project-specific requirements
- e. Test equipment

## PVCMS Task 2: Complete Visual and Mechanical Inspection

### Knowledge of:

- a. Project design
- b. Manufacturer requirements
- c. NEC and local AHJ requirements
- d. Electric service provider requirements (e.g., disconnecting means, interconnection method, equipment location, labeling requirements)

### Skill in:

\* *Verifying installation per project design and requirements*

## PVCMS Task 3: Conduct Mechanical Tests

### Knowledge of:

- a. Installation per torque specifications
- b. Field testing (e.g., pull on driven piles, soil test, concrete slump test)
- c. Witness testing (e.g., module wind or snow loading)

## PVCMS Task 4: Conduct Electrical Tests

### Knowledge of:

- |  |   |
|--|---|
| a. Proper use of diagnostic tools (e.g., multimeter, insulation resistance tester) | g. Continuity testing   |
| b. Insulation resistance testing   | h. Ground resistance test   |
| c. Polarity testing  | i. Wire termination torque verification   |
| d. DC string open circuit voltage (Voc) testing                                    | j. AC voltage testing   |
| e. DC string maximum power current (Imp) testing                                   | k. Witness testing (e.g., functionality of relay, communication to utility, anti-islanding) |
| f. DC string short circuit (Isc) testing   |   |

## PV COMMISSIONING & MAINTENANCE SPECIALIST (PVCMS)

### PVCMS Task 5: Verify System Operation

#### Knowledge of:

- a. Manufacturer startup procedure
- b. Acceptance test and/or performance verification test
- c. Impact of site conditions on testing (e.g., cell temperature readings, plane of array irradiance, power output)
- d. Proper use and calibration requirements of testing equipment

#### Skill in:

- \* *Programming system electronics (e.g., charge controller set points, firmware updates, monitoring system connection, inverter)*
- \* *Calculating expected electrical parameters and comparing to measured values*

### PVCMS Task 6: Confirm Project Completion

#### Knowledge of:

- |  |   |
|--|---|
| a. Finalized documentation (e.g., commission report, signed permits, permission to operate [PTO], photographs) | e. Warranty and owner's documents (e.g., manuals, specification sheets, signed permits) |
| b. Close-out procedures (e.g., punch lists, contract reconciliation, demobilization)                           | f. Equipment identification requirements (e.g., labeling, tags, signage)                |
| c. Owner sign-off requirements (e.g., appropriate site condition, customer satisfaction)                       | g. Operation instructions and/or training for owner                                     |
| d. Accounting requirements (e.g., payment approval, billing, cost coding)                                      | h. Lien release   |
|  | i. Warranty terms and coverage  |
|  | j. System design, operation, and performance metrics (e.g., performance ratio)          |

### PVCMS Task 7: Orient End User to System

#### Knowledge of:

- a. Safe startup, operation, and shutdown procedures
- b. Emergency procedures
- c. Location of components
- d. Monitoring access

#### Skill in:

- \* *Explaining system operation and limitations (e.g., training, operational indicators)*
- \* *Reviewing system and project documentation with end user*



## PV COMMISSIONING & MAINTENANCE SPECIALIST (PVCMS)

### PVCMS Task 8: Verify System Operation Performance

#### Knowledge of:

- a. Access to system monitoring, control, and communications platform(s)
- b. Platform settings and alert mechanisms
- c. Indicators of failure, underperformance, or false alarms
- d. Interpretation of performance data
- e. Seasonal impacts on system performance
- f. Site weather data source
- g. Climate data and impact on performance
- h. Data monitoring system capabilities and instrumentation quality
- i. Performance analytics (e.g., trends)
- j. Remote diagnostics solutions (if available)

### PVCMS Task 9: Perform Preventative Maintenance

#### Knowledge of:

- a. Site access protocol
- b. NFPA 70E (e.g., lock-out/tag-out)
- c. Site-specific safety requirements
- d. Site specific O&M procedure
- e. Periodic visual and mechanical inspection
- f. Instrumentation calibration
- g. Mounting system degradation, failure points and causes (e.g., loose connections, corrosion, displacement)
- h. Module failure points and causes (e.g., signs of overheating, damage to J-Box, discoloration)
- i. Electrical equipment failure points and causes (e.g., vermin, debris, ventilation, water intrusion)
- j. Wiring system degradation, failure points, and causes (e.g., unsupported conductors, connector failure, loose terminations, physical damage to raceway)
- k. Battery system degradation, failure points, and causes (e.g., cable terminations, corrosion, capacity testing, deformation of battery)
- l. Site factors affecting performance (e.g., module soiling, vegetation impacts, shading)
- m. Array testing (e.g., Voc, Isc, Imp, fuse continuity testing)
- n. Comparison of whole system performance to predicted values

### PVCMS Task 10: Perform Corrective Maintenance

#### Knowledge of:

- a. Site access protocol
- b. NFPA 70E (e.g., lock-out/tag-out, personal protective equipment [PPE])
- c. Site-specific safety requirements
- d. Methods for diagnosing failure or low performance (e.g., multimeter, monitoring system, thermal imager)
- e. Methods of repair or replacement
- f. Field modification and equipment substitution
- g. System cleaning (e.g., snow removal, dust/pollen removal)

#### Skill in:

\* *Verifying effectiveness of corrective measures*



NABCEP's mission is to support, and work with, the renewable energy and energy efficiency industries, professionals, and stakeholders to develop and implement quality credentialing and certification programs for practitioners.



*NABCEP's PVIP and SHI Certifications are North America's only renewable energy personnel certification that has been ANSI accredited to the internationally recognized ISO/IEC 17024 standard.*

NABCEP wishes to acknowledge and thank the following individuals for their contribution in developing these JTAs:

*Beth Copanas  
Greg Demarse  
Kevin Flaws  
Chris Giannoumis  
Jeff Gilbert  
Mark Gillespie*

*James Hasslebeck  
Bob Hattier  
Dell Jones  
Jeff Laukhart  
Ernie Pritchard  
Cathy Redson*

*Doug Sabetti  
Phil Schneider  
Rob Smith  
Bob Solger  
Andy Walker*



**North American Board of Certified Energy Practitioners**  
56 Clifton Country Road, Suite 202 Clifton Park, NY 12065  
800-654-0021 / [info@nabcep.org](mailto:info@nabcep.org) / [www.nabcep.org](http://www.nabcep.org)