

Objectives and Task Analysis for the Installer of Grid Connect – Photovoltaic System

Introduction

This document presents an in-depth task analysis (job analysis or key skills analysis) for practitioners who install, and maintain photovoltaic (PV) power generation systems and equipment for grid connect system.

The purpose of this task analysis is to define a general set of competencies and/or skills typically required of practitioners who install and maintain PV systems. Specifically, the task analysis helps establish the basis for training curricula, and helps define requirements for the assessment and credentialing of practitioners. These tasks, or modified version thereof, may be used as guidelines for organisations that wish to train, test, certify, or otherwise qualify existing or new workers to install PV systems. The principal goals of these efforts are to help develop an accredited training infrastructure that produces a knowledgeable, skilled, and experienced workforce, thus helping to ensure the safety, quality, and consumer acceptance of PV installations.

Scope

This task analysis is intended to be all-inclusive of the skills expected for any qualified PV installer, and does not differentiate skills or experience that may be common among existing tradespersons. Furthermore, this list only defines what the tasks are, not how they are accomplished – these issues are mainly dealt with through training and assessment mechanisms. In general, these tasks include fundamental electrical skills expected of journeymen electricians, as well as special skills related to PV technology and its application.

Fundamentally, these tasks assume that the installer begins with adequate documentation for the system design and equipment, including manuals for major components, electrical and mechanical drawings, and instructions. While these tasks have been developed based on conventional designs, equipment, and practice used in the industry today, they do not seek to limit or restrict innovative equipment, designs, or installation practice in any manner. As with any developing technology, it is fully expected that the skills required of the practitioner will develop and change over time, as new materials, techniques, codes, and standards evolve.

Specific tasks in this document are classified as either *cognitive* or *psychomotor* skills for the purposes of identifying the types of training and assessment methods that generally apply. Cognitive skills require knowledge processing, decision-making, and computations, and can

generally be assessed by a written examination. Psychomotor skills require physical actions and hand-eye coordination such as fastening, assembling, measuring, etc, and more appropriately assessed through qualified experience. The tasks are also ranked according to their priority or importance. *Critical* items are considered high priority tasks, and are expected competencies for all PV installers. These include items involving safety and other tasks with a high consequence and high chance of error. *Very Important* items are medium priority tasks, and are generally expected of all competent installers. *Important* items are considered lower priority tasks, but usually performed or understood by the quality installer.

Primary Objective for the PV Installer

Given basic instructions, major components, schematics, and drawings, the PV installer is required to specify, configure, install, inspect, and maintain a grid-connected PV system that meets the performance and reliability needs of the customer, incorporates quality craftsmanship, and complies with all applicable safety codes and standards by:

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1. Working Safely with Photovoltaic Systems		
<i>Task/Skill:</i>	<i>Skill Type:</i>	<i>Priority/Importance:</i>
<i>As part of safety considerations associated with installing and maintaining PV systems, any PV installer must be able to</i>		
1.1 Maintain safe work habits and a clean, orderly work area	Cognitive, Psychomotor	Critical
1.2 Demonstrate safe and proper use of required tools and equipment	Cognitive, Psychomotor	Critical
1.3 Demonstrate safe and accepted practices for personnel protection	Cognitive, Psychomotor	Critical
1.4 Demonstrate awareness of safety hazards and how to avoid them	Cognitive, Psychomotor	Critical
<i>The installer must be able to identify electrical and non-electrical hazards associated with PV installations, and implement preventative and remedial measures to ensure personnel safety.</i>		
1.5 Identify and implement appropriate codes and standards concerning installation, operation, and maintenance of PV systems and equipment	Cognitive, Psychomotor	Critical
1.6 Identify and implement appropriate codes and standards concerning worker and public safety	Cognitive, Psychomotor	Critical
1.7 Identify personal safety hazards associated with PV installations	Cognitive, Psychomotor	Critical
1.8 Identify environmental hazards associated with PV installations	Cognitive, Psychomotor	Critical

2. Interpret System Drawings and System Design		
<i>Task/Skill:</i>	<i>Skill Type:</i>	<i>Priority/Importance:</i>
2.1 Identify and describe all system components from those depicted in a system drawing	Cognitive,	Critical
2.2 Produce a procurement list of all system components from a system drawing	Cognitive,	Critical
2.3 Identify actual location for all equipment to be installed on site	Cognitive,	Critical
2.4 Verify that the array operating voltage range is within acceptable operating limits for power conditioning equipment, including inverters and controllers	Cognitive	Critical

3. Demonstrating installation techniques for all system components		
<i>Task/Skill:</i>	<i>Skill Type:</i>	<i>Priority/Importance:</i>
<i>To demonstrate that they have appropriate practical skills to carry out the installation of all system components the installer must be able to:</i>		
GENERAL		
3.1 Implement all applicable personnel safety and environmental protection measures,	Cognitive	Critical
3.2 Demonstrate an understanding of rules , regulations governing the installation of the equipment and the interconnection to the local electricity utility.	Cognitive	Critical

PV ARRAYS		
3.3	Demonstrate knowledge on how the modules are connected in series and parallel to suit the inverter chosen	Cognitive, Critical
3.4	Demonstrate sound mounting design and techniques for attaching modules to the array frame and the array frame to its supporting structure 3.4.1 use of appropriate bolts or screws, including gauge, penetration 3.4.2 fixing of external timber or metal battens to the roof sub frame 3.4.3 weather sealing of array to building or other support mechanism Note: If BIPV systems installer must be able to install as per specifications.	Cognitive, Psychomotor, Critical
3.5	Assess a site in relation to information from published wind data, and the suitability of the array frame and mounting techniques to meet wind loading requirements	Cognitive, Critical
3.6	Assemble modules, panels, and support structures as specified by module manufacturer or design	Psychomotor, Very Important
3.7	Demonstrate a working knowledge of the pitch and condition of different roof claddings systems, and apply appropriate mounting techniques the roofs typical within the country of installation	Cognitive, Psychomotor, Critical
3.8	Explain how to recognise and avoid corrosion problems arising from contacting dissimilar metals in mounting systems / roof claddings 3.8.1 use of rubber grommets, non-metallic membranes 3.8.2 use of appropriate bolts (stainless steel etc.)	Cognitive, Critical
3.9	Visually inspect and quick test (measure open-circuit voltage) PV modules as required	Psychomotor, Critical

Balance of System Components General		
3.10 Demonstrate the positioning and fixing of all system components (eg Inverter and meters) in place to: 3.10.1 minimise cable lengths between all components 3.10.2 provide an ergonomic system layout 3.10.3 provide a safe working environment and safe installation for the system owners	Cognitive, Psychomotor	Critical
3.11 Layout and secure system components in position 3.11.1 Demonstrate diagrammatically and in practice the layout of system components in ergonomic and economic positions 3.11.2 Discuss the reasons for optimal system component layout 3.11.3 Demonstrate the use of appropriate fixing systems to secure system components in place	Cognitive, Psychomotor	Critical

4. Specifying all system cabling and cable and system protection devices		
<i>Task/Skill:</i>	<i>Skill Type:</i>	<i>Priority/Importance:</i>
<i>To demonstrate that they have a working knowledge of cable specification and cable and system protection devices the installer must be able to:</i>		
4.1 Determine the design currents for any part of a PV system electrical circuit	Cognitive,	Critical
4.2 Explain the reasons why excessive voltage drop can be detrimental to system performance	Cognitive,	Critical
4.3 Discuss current carrying capacity and the implications for cable selection ∴	Cognitive,	Critical
4.4 Demonstrate the calculation and measurement of voltage drop in a conductor	Cognitive,	Critical
4.5 Demonstrate the measurement of current through a conductor	Cognitive, Psychomotor	Critical
4.6 Demonstrate the use of tables to calculate the current carrying capacity of a conductor and the factors which influence CCC	Cognitive,	Critical
4.7 Apply voltage drop and current carrying capacity calculation to select cables for all circuits in a grid connect PV system	Cognitive,	Critical
4.8 Specify appropriate protection for all conductors in a circuit	Cognitive,	Critical
4.9 Determine appropriate size, ratings, and locations for earthing, surge suppression, and associated equipment	Cognitive	Critical
4.10 Determine appropriate size, ratings, and locations for all system overcurrent and disconnect devices	Cognitive	Critical
4.11 Select an appropriate utility interconnection point, and determine the size, ratings, and locations for overcurrent and disconnect devices	Cognitive	Critical

5. Demonstrate practical cabling and final system installation		
<i>Task/Skill:</i>	<i>Skill Type:</i>	<i>Priority/Importance:</i>
<i>To demonstrate that they can carry out installation of cabling, the installer must</i>		
5.1 Demonstrate cable termination techniques	Cognitive, Psychomotor	Critical
5.2 Demonstrate the installation and replacement of circuit protection	Cognitive, Psychomotor	Critical
5.3 Demonstrate safe techniques for laying and securing cables in place	Cognitive, Psychomotor	Very Important
5.4 Demonstrate the use of appropriate physical protection for installed cables	Cognitive, Psychomotor	Very Important
5.5 Install module array interconnect wiring; implement measures to disable array during installation	Psychomotor	Very Important
5.6 Install cabling between modules , inverter and switchboard	Psychomotor	Critical
<i>To complete the installation the installers must be able to:</i>		
5.7 Complete final assembly, structural attachment, and weather sealing of array to building or other support mechanism	Psychomotor	Critical
5.8 Install and provide required labels on inverters, controls, disconnects and overcurrent devices, surge suppression and earthing equipment, junction boxes, batteries and enclosures, conduit, and other electrical hardware	Psychomotor	Critical
5.9 Label, install, and terminate electrical wiring; verify proper connections, voltages, and phase/polarity relationships	Psychomotor	Critical
5.10 Verify continuity and measure impedance of earthing system	Cognitive, Psychomotor	Very Important
5.11 Program, adjust, and/or configure inverters and controls for desired set points and operating modes	Cognitive	Critical

6. Interpreting Technical Standards		
<i>Task/Skill:</i>	<i>Skill Type:</i>	<i>Priority/Importance:</i>
<i>To demonstrate that they are familiar with relevant standards (if applicable) the applicant must be able to:</i>		
6.1 Apply all relevant standards	Cognitive, Psychomotor	Critical
6.2 Own or have reasonable access to relevant Standards and country guidelines Note: All standards and guidelines available within the country are to be included..	Cognitive, Psychomotor	Critical

7. Testing and Commissioning		
<i>Task/Skill:</i>	<i>Skill Type:</i>	<i>Priority/Importance:</i>
<i>After completing the installation of a PV system, as part of system commissioning, inspections and handoff to the owner/operator, the installer shall be able to</i>		
7.1 Visually inspect entire installation, identifying and resolving any deficiencies in materials or workmanship	Cognitive, Psychomotor	Very Important
7.2 Check system mechanical installation for structural integrity and weather sealing	Cognitive, Psychomotor	Critical
7.3 Demonstrate the use of multimeters and other test equipment when undertaking the testing	Cognitive, Psychomotor	Critical
7.4 Check electrical installation for proper wiring practice, polarity, earthing, and integrity of terminations	Cognitive, Psychomotor	Critical
7.5 Activate system and verify overall system functionality and performance; compare with expectations	Cognitive, Psychomotor	Critical
7.6 Demonstrate procedures for connecting and disconnecting the system and equipment from all sources	Cognitive, Psychomotor	Critical
7.7 Identify and verify all required markings and labels for the system and equipment	Cognitive	Critical
7.8 Identify and explain all safety issues associated with operation and maintenance of system	Cognitive	Critical
7.9 Identify what documentation is required to be provided to the PV system owner/operator by the installer	Cognitive	Very Important

8. Maintaining and Troubleshooting a System		
<i>Task/Skill:</i>	<i>Skill Type:</i>	<i>Priority/Importance:</i>
In maintaining and troubleshooting PV systems, the practitioner shall be able to		
8.1 Identify tools and equipment required for maintaining and troubleshooting PV systems; demonstrate proficiency in their use	Cognitive, Psychomotor	Very Important
8.2 Identify maintenance needs and implement service procedures for modules, arrays, power conditioning equipment, safety systems, structural and weather sealing systems, and balance of systems equipment	Cognitive, Psychomotor	Very Important
8.3 Measure system performance and operating parameters; compare with specifications and expectations, and assess operating condition of system and equipment	Cognitive, Psychomotor	Very Important
8.4 Perform diagnostic procedures and interpret results	Cognitive, Psychomotor	Very Important
8.5 Identify performance and safety issues, and implement corrective measures	Cognitive, Psychomotor	Critical
8.6 Verify and demonstrate complete functionality and performance of system, including start-up, shut-down, normal operation, and emergency/bypass operation	Cognitive, Psychomotor	Critical
8.7 Compile and maintain records of system operation, performance, and maintenance	Cognitive	Very Important