Objectives and Task Analysis for the Designer of Grid Connect PV Systems

Introduction

This document presents a task analysis (job analysis or key skills analysis) for practitioners who design Grid Connect PV Systems.

The purpose of this task analysis is to define a general set of competencies and/or skills typically required of practitioners who design Grid Connected 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 design Grid Connect 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 Grid Connected PV system designer, 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. .

Fundamentally, these tasks require that the designer begins with the customers requirements for the PV system and a solar resource assessment for the proposed site. The designer shall then determine the capacity of the PV array , the power rating of the inverter and all balance of equipment to meet the needs of the customer who will use the system. As a minimum the balance of system will typically include an array frame , associated cables and circuit protection equipment. Other skills required to design a system include knowledge of local regulatory requirements for interconnecting systems to the grid and any relevant local standards; ability to do economic analysis of systems capital and operating costs,; production of documentation for the customer and very importantly a knowledge of occupational health and safety requirements.

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 recommended 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 ranked according to their priority or importance. *Critical* items are considered high priority tasks, and are expected competencies for all PV designers. These include items involving determining number of and type of equipment to meet the customers needs. *Very Important* items are medium priority tasks, and are generally expected of all competent designers. *Important* items are considered lower priority tasks, but usually performed or understood by the quality designer.

Primary Objective for the PV Designer

The PV design is required to specify and design a stand alone PV system that meets the performance and reliability needs of the customer, and complies with all applicable safety codes and standards by:

1. Understanding Energy Concepts	
Task/Skill:	***Priority/ Importance:***
In order to design energy based systems, the designers must have understanding and knowledge of the following energy and power concepts	
1.1 Demonstrate knowledge of correct units for energy and power	Critical
1.2 Demonstrate how to convert from one unit to another	Critical
1.3 Demonstrate the use of the prefixes k (1000) and M (mega, 10^6) when converting units	Important
1.4 Identify the power rating of electrical appliances when presented with this information in different formats. e.g. as W or as A (if the voltage is given	Important
1.5 Calculate the effective energy consumption from power rating and operating times .	Important

2. Determine the Requirements of the Customer and Energy (Electrical) Use of the Site	
Task/Skill:	***Priority/ Importance:***
In determining the requirements of the customer, the designer shall be able to;	
2.1 Survey the customer to determine what are their reasons for installing a PV Grid Connects System.	Very Important
In determining the Electrical Usage at the site, the designer shall be able to	
2.2 Understand local utility energy metering and interpret billing notices	Important
2.3 Demonstrate understanding of how to install metering equipment to determine the sites energy (electrical) usage	Important

3. Determining Solar Resources	
Task/Skill:	***Priority/ Importance:***
To demonstrate appropriate skills and knowledge of photovoltaic energy resources the designer must be able to:	
3.1 Access and interpret solar radiation data available from different sources	Very Important
3.2 Define the term 'peak sun hours' (irradiation) and be able to quantify the daily total peak sun hours to array orientation, inclination and time of the year	Very Important
3.3 Quantify the impact of shading on the available peak sun hours for a sample site	Very Important

4. Undertaking System Design	
Task/Skill:	***Priority/ Importance:***
To Demonstrate that they are familiar with the design process and all factors which influence the design of a grid connected PV system the applicant must be able to:	
PV ARRAYS	
4.1 Interpret the technical specifications and output characteristics of photovoltaic modules and understand the terms Isc, Voc, Imp, Vmp, Pmax	Very Important
4.2 Define the factors which influence the output characteristics of photovoltaic modules (irradiance, temperature, dirt, manufactures tolerance and age)	Important
4.3 Compare the relative merits of alternative photovoltaic modules for different applications and installation requirements. Compare the generic alternatives of the following classes, and compare different manufacturers' data within the classes, viz: 4.3.1 monocrystalline 4.3.2 polycrystalline 4.3.3 amorphous (thin film) 4.3.4 other technologies eg concentrator technologies	Important
4.4 Demonstrate basic electric circuit theory and be able to identify series and parallel circuits	Very Important
4.5 Demonstrate the effect on array output (current, voltage and power) of connecting modules in series and parallel configurations	Very Important
4.6 Explain the effects of using dissimilar modules in an array	Very Important

4.7 Demonstrate the use of blocking and bypass diodes with the different classes of PV modules, and make appropriate decisions about their use or otherwise and quantify the effect of diodes on array output.	Very Important
4.8 Demonstrate the impact of shading and implement a program to periodically check for shading effects by cleaning panels, removing debris (leaves bird droppings etc.), trimming trees	Critical
4.9 Explain the design criteria and installation techniques for ground mounted array frames and supports 4.9.1 footings 4.9.2 wind loading	Very Important
4.10 Demonstrate sound mounting design and techniques for attaching modules to the array frame and the array frame to its supporting structure 4.10.1 use of appropriate bolts or screws, including gauge, penetration 4.10.2 fixing of external timber or metal battens to the roof sub frame	Very Important
4.11 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	Critical
4.12 Demonstrate a working knowledge of the pitch and condition of different roof claddings systems, and apply appropriate mounting techniques for 4.12.1 Building Integrated 4.12.2 steel decking 4.12.3 corrugated iron 4.12.4 terra cotta and concrete tiles 4.12.5 wood shingles 4.12.6 slate 4.12.7 concrete roofs or tank tops **Note: This list is to include the typical types of roofs in the country where the task analysis is to be applied.**	Very Important
4.13 Explain how to recognise and avoid the corrosion problems arising from contacting dissimilar metals in mounting systems / roof claddings 4.13.1 use of rubber grommets, non-metallic membranes 4.13.2 use of appropriate bolts (stainless steel etc.)	Very Important

4.14	Demonstrate by the use of diagrams the layout of a PV array to cater for different shaped roofs	Very Important
4.15	Discuss the different methods of fixing PV arrays at optimum pitch and orientation to off roof pitches and orientations	Very Important
4.16	Select the array tilt angles and orientation to optimise the array output	Very Important
4.17	Calculate the expected average daily output of a given array for the selected installation parameters (tilt and orientation vs. season)	Critical
Balance of Systems Inverters		
4.18	Demonstrate an understanding of the basic operating principles of inverters	Very Important
4.19	Determine required inverter specifications from size of PV array	Critical
4.20	List the factors which affect the efficiency and reliability of inverters, and their minimum location and housing requirements	Very Important
4.21	Demonstrate an understanding of the Maximum Power Point Tracking feature of grid connect inverters	Important
4.22	Demonstrate a working knowledge of inverter specifications and features –over and under voltage and frequency controls, harmonic distortion, stand-by power consumption, status-indicating, metering, data-logging and programming functions - and understand the problems associated with audible noise, radio frequency interference	Very Important
4.23	Demonstrate a working knowledge of the effect on Inverter efficiency on energy output of the system. a	Critical
4.24	Demonstrate with a working knowledge of the specifications, installation requirements and controls for a range of commercially available inverters	Very Important
Balance of Systems System Cabling and Circuit Protection and metering		
4.25	Demonstrate the ability to calculate voltage drop for a cable.	Critical
4.26	Explain the reasons why excessive voltage drop can be detrimental to system performance and calculate the effect of cable losses on the average daily output of the system	Critical

4.27 Discuss current carrying capacity and the implications for cable selection	Critical
4.28 Demonstrate the use of tables to calculate the current carrying capacity of a conductor and the factors which influence CCC	Critical
4.29 Specify appropriate protection for all conductors in a circuit	Critical
4.30 Specify appropriate interconnection to the utility grid	Critical
4.31 Demonstrate knowledge of different ways that the system could be metered these include: o measuring all the energy from system o measuring only the energy that is supplied to the grid o combination of the two	Very Important
System Performance-Component Matching	
4.32 Matching Voc and Vmp of array to the operating and maximum voltages of the inverter.	Critical
4.33 Matching Imp and Isc of array to the operating current of the inverter.	Critical
4.34 Matching output power of array to power rating of inverter.	Critical
Determining Overall System Performance	
4.35 Calculate the expected average daily output of the total system for the selected array (tilt and orientation), inverter and cabling installation parameters for each month of the year and the then expected yearly energy yield.	Critical
4.36 Calaculte performance ratio	

5. Interpreting Technical Standards	
Task/Skill:	***Priority/ Importance:***
To demonstrate that they are familiar with relevant standards (if applicable) the applicant must be able to:	
5.1 Apply all relevant standards	Critical

5.2 Own or have reasonable access to relevant Standards and country guidelines **Note: All standards and guidelines available within the country are to be included..**	Critical

6. Undertaking Economic Analysis	
Task/Skill:	***Priority/ Importance:***
To demonstrate that they can carry out an economic analysis of the system design and its projected performance the applicant must be able to:	
6.1 Calculate the capital costs of the system equipment and installation.	Critical
6.2 Calculate expected running costs of the system	Critical
6.3 Calculate expected replacement costs and a timetable for replacement of all system components	Important
6.4 Calculate the life cycle costs of then system	Important

7. Interpreting Regulatory Requirements	
Task/Skill:	***Priority/ Importance:***
To demonstrate that they have a working knowledge of regulatory requirements the applicant must be able to	
7.1 Demonstrate awareness of the range of government planning or other requirements which may impact on the viability of a planned system **Note: This should contain the relevant requirements for the country**	Very Important
7.2 Demonstrate and awareness of the ELV and LV limits and the requirement for all LV work to be carried out by or under the supervision of a licensed electrical contractor **Note: Only if relevant in the country**	Critical

8. Knowledge of Occupational Health and Safety	
Task/Skill:	***Priority/ Importance:***

To demonstrate that they are familiar with and can apply occupational health and safety requirements the applicant must be able to	
8.1 Carry out a Job Safety analysis:- 8.1.1 Identify job tasks 8.1.2 Identify hazards 8.1.3 Identify the risk class 8.1.4 Nominate risk control measures 8.1.5 Nominate a person responsible for carrying out each measure	Critical
8.2 Be aware of any local OHS legislation (if relevant) and its application to the sustainable energy industry	Critical
8.3 Use defined safe working practices (particularly relating to the hazards of height, heavy weights, explosive gases, electric shock and burns)	Critical

9. Developing Documentation	
Task/Skill:	***Priority/ Importance:***
To Demonstrate that they are familiar with system documentation the designer must be able to	
9.1 State the system documentation that should be provided to the system owners	important