Objectives and Task Analysis for a Professional Small Wind Energy System Installer
Final draft by the NABCEP Small Wind Committee 10-6-08

Introduction

This document presents an in-depth task analysis for practitioners who do wind site assessments, and specify, install and maintain wind energy systems and equipment.

Purpose and Scope

The purpose of this task analysis is to define a general set of knowledge, skills and abilities typically required for small wind system practitioners, and to help ensure safety, quality and consumer acceptance of small wind installations throughout the U.S. This task analysis 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 version thereof, may be used by states or organizations that wish to develop requirements for education, training, testing, certification or otherwise qualify existing or new workers to install small wind energy systems.

This task analysis is intended to be all-inclusive of the skills expected for any qualified professional small wind system installer. A small wind energy system is defined as being a grid connected or off-grid system with or without batteries rated at 100 kW or less

Although these tasks are primarily targeted toward the installer as opposed to the system designer, in many cases the installer must be knowledgeable about many aspects of systems design, and may be required to adapt designs and equipment to fit a particular application or customer need, and often are required to select and specify balance-of-system (BOS) components. For this reason, the task analysis includes several items involving the verification of the system designs. Safety standards, electrical codes and accepted industry practice are central to this task analysis, and are implicit to nearly every task.

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, supervised experience or apprenticeship. The tasks are also ranked according to their priority or importance using three levels: *Critical* items are considered very high priority tasks, and are expected competencies for all small wind energy installers. These include items involving safety and other tasks with a high consequence and high chance of error. *Very Important* items are high priority tasks, are generally expected of all quality installers, and have either a medium or high consequence and a high chance of error. *Important* items are considered medium priority tasks that are usually performed by all qualified installers and have a medium or low consequence and medium or low chance of error.

Primary Objective for the Small Wind Energy Installer

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

1. Conducting a Wind Energy Site Assessment		
Task/Skill:	***Skill Type:***	***Priority/ Importance:***
In conducting a site assessment for a small wind energy system, the wind energy site assessor or wind system installer shall be able to:		
1.1 Identify typical tools and equipment required for conducting site assessments for small wind energy systems, including computer skills, spreadsheets, topographic and wind speed maps, aerial photographs, and wind speed calculators, and demonstrate proficiency in their use.	Cognitive	Important
1.2 Quantify the customer electrical load and energy use through review of utility bills, meter readings, measurements, and/or customer interview	Cognitive, Psychomotor	Important
1.3 For new construction, estimate electric load based on building characteristics and electric equipment needs	Cognitive	Important
1.4 Identify opportunities incorporating energy efficient equipment or appliances, conservation, and energy management practices.	Cognitive, psychmotor	Important
1.5 Determine the location and impact of buildings, trees, local terrain, and other obstacles at the client's site, and suggest solutions to overcome their interference	Cognitive, psychomotor	Critical
1.6 Identify whether the site is suitable for a wind system	Cognitive	Critical
1.7 Estimate the wind shear at a client's site based on local terrain, ground clutter, and best available wind resource map	Cognitive	Critical
1.8 Calculate wind shear based on wind speed data for two or more heights	Cognitive, psychomotor	Critical
1.9 Determine the minimum acceptable tower height for the client's site based on terrain and obstacles	Cognitive	Very Important
1.10 Determine average annual wind speed at the specified tower height based on the most currently available wind maps, wind speed data, and computer programs	Cognitive	Very Important
1.11 Interpret wind speed and turbulence data (and altitude data, if relevant) for the client's site for the purpose of establishing performance expectations and use in wind system output calculations	Cognitive	Important
1.12 Specify several wind turbine system options that would be suitable for the client's energy needs as well as their technical experience and expertise	Cognitive	Important
1.13 Evaluate and/or measure the peak load demand and average daily energy use for all loads directly connected to the inverter-battery system for the purposes of sizing equipment for off-grid systems	Cognitive, psychomotor	Critical
1.14 Identify one or more potential locations for a small wind energy system at a client's home site	Cognitive, Psychomotor	Very Important

1.15	Diagram site plan to include tower location relative to existing homes and site features	Cognitive	Very Important
1.16	Identify any site-specific safety hazards or other issues associated with the installation of the wind turbine, tower, and associated equipment, including underground water, gas, LP, sewer, and telephone lines	Cognitive	Very Important
1.17	Identify a suitable wire run from the tower base to the location of the control systems and electronics	Cognitive	Very Important
1.18	Estimate turbine output performance for the client, including impact on their utility bill for on-grid systems, or energy contributions to an off-grid battery charging system	Cognitive	Critical
1.19	Research utility interconnection requirements for the wind system, and how they will apply to the client	Cognitive	Important
1.20	Identify any potential zoning or building permit requirements or limitations and how they will effect the wind turbine installation.	Cognitive	Important
1.21	Determine the proximity of any nearby airports and the need to apply to the Federal Aviation Administration for a determination letter prior to constructing permission to construct the tower	Cognitive	Very Important
1.22	Identify any concerns about soil type or depth to bedrock for suitability of the tower foundation and/ or footings	Cognitive, Psychomotor	Critical
1.23	Determine the need for any appropriate setbacks from overhead utility lines, road right-of-ways, or property lines, if applicable	Cognitive, psychomotor	Important
1.24	Explain wind turbine technologies and component parts, and the basic physics behind their operation	Cognitive	Very Important
1.25	Identify current technologies appropriate for the site and the client, for the purpose of providing several system options	Cognitive	Very Important
1.26	Explain the maintenance requirements for the small wind energy systems specified	Cognitive	Important
1.27	Track current pricing of small wind energy systems and components for the purpose of providing the client with rough cost estimates.	Cognitive	Important
1.28	Produce a written report detailing an estimate of the client's wind resource, the minimum acceptable tower height at the client's site, wind speed at that height, opportunities for energy efficiency and/or conservation, possible system and equipment options, and potential technical, zoning, or social barriers to the installation of the small wind energy system	Cognitive	Critical
1.29	Identify potential incentives, grants, and other funding sources that may be available to the client	Cognitive	Important
1.30	Identify any educational resources or opportunities that might be of help to the client	Cognitive	Important
1.31	Identify a list of next steps for the client to follow as they progress through the installation process.	Cognitive	Important

2. Working Safely With Small Wind Energy Systems		
Task/Skill:	***Skill Type:***	***Priority/ Importance:***
As part of safety considerations associated with installing and maintaining small wind energy systems, a wind energy installer must be able to:		
2.1 Maintain safe work habits, a clean shop area, and a clean area at the installation site	Cognitive, Psychomotor	Critical
2.2 Demonstrate safe and proper use of required tools and equipment	Cognitive, Psychomotor	Critical
2.3 Identify electrical and non-electrical personal work zone safety issues associated with wind system installations, and how to avoid them	Cognitive, Psychomotor	Critical
2.4 Demonstrate safe and proper practices in working with wind turbines, towers, and associated electrical and mechanical equipment	Cognitive, Psychomotor	Critical
2.5 Identify and implement safe and accepted practices for worker and work zone safety	Cognitive, Psychomotor	Critical
2.6 Identify and mitigate public safety issues during wind system installations	Cognitive	Critical
2.7 Identify environmental considerations associated with wind system installations	Cognitive, Psychomotor	Critical
2.8 Determine if weather conditions could cause unsafe work conditions.	Cognitive	Critical

3. Selecting a Final System Design		
Task/Skill:	***Skill Type:***	***Priority/ Importance:***
Based on results from a site survey and customer requirements and expectations, the installer shall be able to:		
3.1 Identify appropriate system designs/configurations for the wind turbine and tower based on the client needs, expectations, and site considerations	Cognitive	Very Important
3.2 Possess appropriate math skills to be able to lay out any tower configuration at the client's site, including guy lengths for guyed towers, selecting proper earth anchors for the soil type and calculate concrete requirements for both guyed and mono-pole structures.	Cognitive	Very Important
3.3 For on-grid systems, determine all applicable interconnection requirements.	Cognitive	Important
3.4 For off-grid systems, estimate sizing requirements for the wind turbine, battery bank, gen-set, and inverters based on customer load, desired energy or peak power production, autonomy requirements, and cost, as applicable	Cognitive, Psychomotor	Very Important
3.5 Establish suitable locations and diagram possible layouts for installing inverters, controllers, batteries, other balance of system components, disconnect switches, metering and logging devices, and other electronics	Cognitive, Psychomotor	Very Important

3.6	Determine requirements for installing additional sub-panels and interfacing the wind system with the utility service, and/or other generating sources as applicable	Cognitive, Psychomotor	Very Important
3.7	Determine the impact of a wind component in a hybrid renewable energy system, and estimate energy output for wind component of the hybrid system	Cognitive, Psychomotor	Very Important
3.8	Identify and select major balance-of-system components required for the installation	Cognitive	Very Important
3.9	Identify and select appropriate system monitoring equipment, including energy monitor and wind speed indicator or datalogger	Cognitive	Very Important
3.10	Determine the installation sequence to optimize use of time and materials	Cognitive	Very Important
3.11	Estimate time, materials, and equipment required for the installation, and provide an appropriate price bid	Cognitive	Very Important

4. Adapting the Mechanical Design			
Task/Skill:		***Skill Type:***	***Priority/ Importance:***
In adapting a small wind system, the installer shall be able to:			
4.1	Identify equipment to be used in the installation that is consistent with environmental, structural, code requirements, acceptable safety protocol, and other conditions at the site	Cognitive	Important
4.2	Identify appropriate tower location, wire run, electrical configuration, tower set backs, and maintenance considerations at the site	Cognitive, Psychomotor	Important
4.3	Determine if and when a soil analysis is required to properly specify, configure, and engineer a suitable foundation or footings for the tower.	Cognitive	Very Important
4.4	Determine if and when the foundation or footings need to be adjusted based on soil type, excavation characteristics or depth to bedrock, and who to consult to obtain the proper foundation or footing specifications	Cognitive	Very Important

5. Adapting the Electrical Design			
Task/Skill:		***Skill Type:***	***Priority/ Importance:***
In adapting a small wind energy electrical design, the installer shall be able to:			
5.1	Check the local utility interconnection requirements, and be able to design the system to satisfy those requirements	Cognitive	Very Important
5.2	Select appropriate conductor types and ratings for each electrical circuit in the system based on application or manufacturer specifications	Cognitive, Psychomotor	Critical

5.3	Where appropriate, determine the de-rated ampacity of system conductors based on NEC requirements	Cognitive	Critical
5.4	Determine appropriate size, ratings, and locations for all system over-current and disconnect devices	Cognitive	Critical
5.6	Determine the appropriate grounding system for the wind turbine and tower as specified by the equipment manufacturer, NEC, or best practices, as appropriate	Cognitive	Critical
5.7	Determine appropriate size, ratings, and locations for grounding, lightning protection, surge suppression, and associated equipment as specified by the manufacturer and/or the NEC	Cognitive	Critical
5.8	Determine the minimum acceptable wire size for all electrical circuits as specified by the manufacturer and/or the NEC	Cognitive	Very Important

6. Installing Subsystems and Components at the Site			
Task/Skill:		***Skill Type:***	***Priority/ Importance:***
As part of a small wind energy system installation process, the installer shall be able to:			
6.1	Utilize any drawings, schematics, instructions, installation manuals, mathematics, or recommended procedures in installing equipment	Cognitive	Critical
6.2	Utilize a check list to assure that all aspects of the installation have been performed	Cognitive	Very important
6.3	Implement all applicable work zone safety and environmental protection measures and protocols during installation	Cognitive	Critical
6.4	Utilize appropriate math skills to lay out the tower and foundation	Cognitive, Psychomotor	Important
6.5	Excavate, properly form, set rebar reinforcement, pour, and properly backfill the tower foundation per the tower supplier's specifications, or be able to oversee such activities as carried out by a concrete contractor.	Psychomotor	Very Important
6.6	Visually inspect the tower and components, wind turbine, wiring, lightning protection, disconnect and over-current protection devices, inverters, batteries, and balance of system components for readily identifiable problems before installation	Psychomotor	Very Important
6.7	Test the wind turbine for voltage and current output, as appropriate, before installing	Psychomotor	Critical
6.8	Assemble the tower and wind turbine as specified by the appropriate equipment manufacturers or suppliers	Psychomotor	Critical
6.9	For crane installations, utilize crane operator signals and protocol, and be able to communicate with the crane operator during the tower and turbine lift	Cognitive, Psychomotor	Critical

6.10	For tilt-up tower installations, implement the installation process and safety considerations unique to the equipment and situation	Cognitive, Psychomotor	Very Important
6.11	Determine the installation process, equipment, and safety considerations unique to stacking tower installations.	Cognitive, Psychomotor	Critical
6.12	Measure and check that the tower is straight and plumb	Cognitive, Psychomotor	Very important
6.13	Check fasteners and guy cables for proper tension using appropriate standards and or the manufacturer recommendations when provided	Cognitive, Psychomotor	Critical
6.14	Install the wiring for the turbine, tower, and wire run, disconnect switches, and over-current protection devices	Psychomotor	Critical
6.15	Complete the final assembly and installation of all electrical components, inverters, controllers, disconnects and over-current devices, surge and lightning arrestors, grounding equipment, junction boxes, batteries and enclosures, conduit and other electrical hardware, anemometers, and energy and wind monitoring equipment	Psychomotor	Critical
6.16	Label, install, and terminate electrical wiring, verify proper connections, voltages, and phase/polarity relationships	Psychomotor	Critical
6.17	Verify continuity of the grounding system	Cognitive, Psychomotor	Very Important
6.18	Program, adjust, and configure inverters and controllers for desired set-points and operating modes, as appropriate	Cognitive, psychomotor	Critical

7. Performing a System Checkout and Inspection		
Task/Skill:	***Skill Type:***	***Priority/ Importance:***
After completing the installation of the wind energy system, as part of system commissioning, inspections and handoff to the owner/operator, the practitioner shall be able to:		
7.1 Visually inspect entire installation, identifying and resolving any deficiencies in materials or workmanship	Cognitive, Psychomotor	Very Important
7.2 Visually check the mechanical installation for structural integrity	Cognitive, Psychomotor	Critical
7.3 Verify the electrical installation for proper wiring practice, polarity or phase relationships, grounding, and integrity of terminations	Cognitive, Psychomotor	Critical
7.4 Verify if an electrical inspection by either a licensed electrician, electrical inspector, or the utility is required before system commissioning, and if so, be present during such inspection	Cognitive, Psychomotor	Critical
7.5 Activate the system in proper start-up sequence and verify overall system functionality	Cognitive, Psychomotor	Critical
7.6 Provide an electrical diagram for the system, and explain it to the owner or operator of the wind system	Cognitive, psychomotor	Important

7.7	Demonstrate and post in writing the procedures for connecting and disconnecting the system and equipment from all electrical sources	Cognitive, psychomotor	Very Important
7.8	Demonstrate and post in writing shut-down procedures for use by the owner or operator, and emergency personnel if required	Cognitive, psychomotor	Very Important
7.9	Identify and verify all required markings and labels for the system and equipment	Cognitve	Critical
7.10	Identify, explain, and/or leave in writing all operator or worker safety issues associated with the operation and maintenance of the system, as appropriate	Cognitve, psychomotor	Very Important
7.11	Identify all documentation to be provided to the wind system owner or operator by the installer, including installation, operations, and maintenance manuals, and warranties	Cognitive	Very Important
7.12	Observe and listen to the turbine and equipment to determine that the system is operating correctly.	Cognitive, Psychomotor	Very Important
7.13	Check fasteners and guy cables for proper tension using appropriate standards and or the manufacturer recommendations when provided.	Cognitive, Psychomotor	Critical
7.14	Secure guy cable turnbuckles with “figure 8” safety loops	Psychomotor	Critical

8. Maintaining and Troubleshooting			
Task/Skill:		***Skill Type:***	***Priority/ Importance:***
In maintaining and troubleshooting a small wind energy system, the installer shall be able to:			
8.1	Identify tools and equipment required for maintaining and troubleshooting wind energy systems and demonstrate proficiency in their use	Cognitive, Psychomotor	Very Important
8.2	Identify maintenance needs and implement service procedures for the tower, fasteners, guy cables, wind turbine, wiring, grounding system, lightning protection, batteries, power conditioning equipment, safety systems, and balance of system equipment	Cognitive, Psychomotor	Very Important
8.3	Measure system output and operating parameters, compare with specifications and expectations, and assess the operating condition of the system and components, if appropriate	Cognitive, Psychomotor	Very Important
8.4	Perform mechanical and electrical diagnostic procedures and interpret results	Cognitive, Psychomotor	Very Important
8.5	Identify performance issues and safety concerns, and implement corrective measures	Cognitive, Psychomotor	Critical
8.6	Verify and demonstrate complete functionality and performance of the system, including start-up, shut-down, normal operation, and emergency or bypass operation	Cognitive, Psychomotor	Critical
8.7	Compile and maintain records of system maintenance and repairs, and provide a copy to the owner or operator	Cognitive	Very Important