

## **Objectives and Task Analysis for a Small Wind Energy System Installer**

### **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 small wind system installer. A small wind energy system is defined as being 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 grid-connected or off-grid 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 ..... 3**
- 2. **WORKING SAFELY WITH SMALL WIND ENERGY SYSTEMS ..... 3**
- 3. **SELECTING A FINAL SYSTEM DESIGN ..... 5**
- 4. **ADAPTING THE MECHANICAL DESIGN ..... 6**
- 5. **ADAPTING THE ELECTRICAL DESIGN ..... 6**
- 6. **INSTALLING SUBSYSTEMS AND COMPONENTS AT THE SITE ..... 7**
- 7. **PERFORMING A SYSTEM CHECKOUT AND INSPECTION ..... 8**
- 8. **MAINTAINING AND TROUBLESHOOTING ..... 8**

<b>1. Conducting a Wind Energy Site Assessment</b>		
<i>Task/Skill:</i>	<i>Skill Type:</i>	<i>Priority/Importance:</i>
<b><i>In conducting a site assessment for a small wind energy system, the wind energy site assessor or wind system installer shall be able to:</i></b>		
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 Identify opportunities incorporating energy efficient equipment or appliances, conservation, and energy management practices	Cognitive	Critical
1.4 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	Important
1.5 Understand and be able to estimate the wind shear at a client's site based on local terrain and ground clutter	Cognitive	Very Important
1.6 Determine the minimum acceptable tower height for the client's site based on terrain and obstacles	Cognitive	Very Important
1.7 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
1.8 Interpret wind speed 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
1.9 Specify several wind turbine system options that would be suitable for the client's energy needs as well as technical experience and expertise	Cognitive	Important
1.10 Estimate 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	Very Important
1.11 Identify several suitable locations for a small wind energy system at a client's home site	Cognitive, Psychomotor	Very Important
1.12 Diagram tower location relative to existing homes and site features	Cognitive	Very Important
1.13 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
1.14 Identify a suitable wire run from the tower base to the location of the control systems and electronics	Cognitive	Very Important
1.15 Estimate turbine output performance for the client, including impact on the their utility bill for on-grid systems, or energy contributions to an off-grid battery charging system	Cognitive	Important
1.16 Research utility interconnection requirements for the wind system, and how they will apply to the client	Cognitive	Important

1.17	Identify any potential zoning barriers or building permit obstacles	Cognitive	Important
1.18	Determine the proximity of any nearby airports and the need to apply to the Federal Aviation Administration for permission to construct the tower	Cognitive	Very Important
1.19	Identify any concerns about soil type or depth to bedrock for suitability of the tower foundation and/ or footings	Cognitive, Psychomotor	Critical
1.20	Determine the need for any appropriate setbacks from overhead utility lines, road right-of-ways, or property lines, if applicable	Cognitive	Important
1.21	Be familiar with wind turbine technologies and component parts, and have an understanding of the physics behind their operation	Cognitive	Very Important
1.22	Be familiar with current technologies appropriate for the site and the client, for the purpose of providing several system options	Cognitive	Very Important
1.23	Be familiar with the maintenance requirements for the small wind energy systems specified	Cognitive	Important
1.24	Be familiar with current pricing of small wind energy systems and components for the purpose of providing the client with rough cost estimates.	Cognitive	Important
1.25	Produce a written report detailing an estimate of the client's wind resource, the minimum acceptable tower height at the clients 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	Very Important
1.26	Identify potential incentives, grants, and other funding sources that may be available to the client	Cognitive	Important
1.27	Identify any educational resources or opportunities that might be of help to the client	Cognitive	Important
1.28	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 safety hazards 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	Implement preventive and remedial measures to ensure personnel safety	Cognitive, Psychomotor	Critical
2.6	Demonstrate safe and accepted practices for personnel protection	Cognitive, Psychomotor	Critical
2.7	Identify and implement safe and accepted practices for worker safety	Cognitive, Psychomotor	Critical
2.8	Demonstrate proficiency in basic first aid and CPR	Cognitive, Psychomotor	Important
2.9	Identify public safety hazards associated with wind system installations	Cognitive	Very Important
2.10	Identify environmental hazards associated with wind system installations	Cognitive, Psychomotor	Very Important

<b>3. Selecting a Final System Design</b>			
<i>Task/Skill:</i>		<i>Skill Type:</i>	<i>Priority/Importance:</i>
<b><i>Based on results from a site survey and customer requirements and expectations, the installer shall be able to:</i></b>			
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	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	Identify the suitability, location, and approximate system size for a photovoltaic component in a wind/PV hybrid system, and estimate energy output for all components 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

<b>4. Adapting the Mechanical Design</b>			
<i>Task/Skill:</i>		<i>Skill Type:</i>	<i>Priority/Importance:</i>
<b><i>In adapting a small wind system, the installer shall be able to:</i></b>			
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	Understand if and when a soil analysis is required to properly specify, configure, and engineer a suitable foundation or footings for the tower.	Cognitive, Psychomotor	Very Important
4.4	Understand if and when the foundation or footings need to be adjusted based on soil type or depth to bedrock, and who to consult to obtain the proper foundation or footing specifications	Cognitive, Psychomotor	Very Important

<b>5. Adapting the Electrical Design</b>			
<i>Task/Skill:</i>		<i>Skill Type:</i>	<i>Priority/Importance:</i>
<b><i>In adapting a small wind energy electrical design, the installer shall be able to:</i></b>			
5.1	Be familiar with the local utility interconnection guidelines, 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	Cognitive, Psychomotor	Critical
5.3	Where appropriate, determine the de-rated ampacity of system conductors, and select appropriate sizes based on design currents,	Cognitive	Critical
5.4	Determine appropriate size, ratings, and locations for all system over-current and disconnect devices	Cognitive	Critical
5.5	Understand the appropriate grounding system for the wind turbine and tower as specified by the equipment manufacturer	Cognitive	Critical

5.6	Determine appropriate size, ratings, and locations for grounding, lightning protection, surge suppression, and associated equipment	Cognitive	Critical
5.7	Where appropriate, determine minimum acceptable voltage drop for all electrical circuits based on size and length of conductors, and adjust accordingly	Cognitive	Very Important
<b>6. Installing Subsystems and Components at the Site</b>			
<b>Task/Skill:</b>		<b>Skill Type:</b>	<b>Priority/Importance:</b>
<i>As part of a small wind energy system installation process, the installer shall be able to:</i>			
6.1	Utilize drawings, schematics, instructions mathematics and recommended procedures in installing equipment	Cognitive	Critical
6.2	Implement all applicable personnel safety, environmental protection, and public safety protection equipment, measures, and protocol	Cognitive	Critical
6.3	Utilize appropriate math skills to lay out the tower	Cognitive, Psychomotor	Important
6.4	Excavate, properly form, 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
6.5	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
6.6	Test the wind turbine for voltage and current output	Psychomotor	Critical
6.7	Assemble the tower and wind turbine as specified by the appropriate equipment manufacturers or suppliers	Psychomotor	Critical
6.8	For crane installations, understand crane operator signals and protocol, and be able to communicate with the crane operator during the tower and turbine lift	Cognitive, Psychomotor	Critical
6.9	For tilt-up tower installations, understand the installation process and safety considerations unique to the equipment and situation	Cognitive, Psychomotor	Very Important
6.10	Install the turbine, tower, and underground wiring, disconnect switches, and over-current protection devices	Psychomotor	Critical
6.11	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
6.12	Label, install, and terminate electrical wiring, verify proper connections, voltages, and phase/polarity relationships	Psychomotor	Critical

6.13	Verify continuity and measure impedance of the grounding system	Cognitive, Psychomotor	Very Important
6.14	Program, adjust, and configure inverters and controllers for desired set-points and operating modes	Cognitive	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	Check the mechanical installation for structural integrity	Cognitive, Psychomotor	Critical
7.3	Check 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	Develop an electrical diagram for the system, and explain it to the owner or operator of the wind system	Cognitive	Important
7.7	Demonstrate and post in writing procedures for connecting and disconnecting the system and equipment from all sources	Cognitive	Very Important
7.8	Demonstrate and post in writing shut-down procedures for the owner, operator, emergency rescue squad, or fire department personnel	Cognitive	Very Important
7.9	Identify and verify all required markings and labels for the system and equipment	Cognitive	Critical
7.10	Identify, explain, and leave in writing all safety issues associated with the operation and maintenance of the system	Cognitive	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	Identify items to look and listen for to identify when the system is not operating correctly or malfunctioning	Cognitive, Psychomotor	Very Important

## 8. Maintaining and Troubleshooting

*Task/Skill:*

*Skill Type:*

*Priority/Importance:*



<b><i>In maintaining and troubleshooting a small wind energy system, the installer shall be able to:</i></b>			
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, 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	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