NABCEP

Small Wind

Installer Certification
Exam Resource Guide

www.nabcep.org

North American Board of NABCEP Certified Energy Practitioners®

Successfully achieving NABCEP small wind installer certification requires a combination of training, experience, and testing.

The small wind installers' exam is based on the task analysis, which was developed by the small wind technical committee and vetted by a number of small wind stakeholders. Stakeholders included successful installers, manufacturers, supply chain companies, public benefits program administrators, state energy offices, and small wind advocates.

The task analysis is meant to be a blueprint of the various skills required by an installer to successfully and safely install any small wind-electric system. "Small wind" is defined as any wind turbine from 1 kW to 100 kW in nameplate capacity (roughly 8 to 70 feet in rotor diameter). Small wind includes many tower styles and sizes, including freestanding, guyed, and tilt-up, and with no upper height limit. It includes battery-less grid-tied systems and off-grid battery-based systems, and many variations in between, with a very wide range of equipment and applications.

Safety plays no favorites and doesn't differentiate between short tilt-up towers or tall freestanding ones, nor for that matter, between big or small electrical shorts. All accidents, oversights, and improperly installed equipment have the potential for dire outcomes. For this reason, we urge exam candidates to become fully conversant with all safety considerations and practices involved in the installation of small wind equipment. It is the hope of the Small Wind Resource Guide committee that installers and their crews work carefully and attentively at all times, and help to maintain the remarkably good track record that our industry has managed over the past thirty-plus years.

This resource guide lists books, magazines, and web sites that should be helpful to anyone interested in installing small wind-electric systems. The resource guide committee has chosen what it feels are useful references for the skills, knowledge set, and practices cited in the task analysis. Like you, the committee has no idea what is on the small wind installer's examination. However, we are confident that a working knowledge of the content of the resources we have listed will go a long way to successfully and safely installing any small wind-electric system, and prepare you for taking the exam. Networking with other small wind installers—sharing what works and what doesn't work—is another valuable resource that any person seeking small wind installer certification should engage in. Books and web sites are no replacement for experience. As the saying goes "Good judgment comes from experience; experience comes from bad judgment."

The resources listed are categorized as "general" and "specific." The general resources are those at the head of the task analysis. A competent small wind installer should be quite familiar with these resources. Specific resources are those that show up in the individual sections of the task analysis, are supplemental to the primary resources, and pertinent to the section in which they are listed.

The resources have not been prioritized or weighted in any way—all of them are of significant value, and you should become familiar with them all. You may also have a working knowledge of your own favorite resources that have served you well for small wind installations. Please realize that these are resources, not study manuals or keys that will unlock the small wind installer exam questions.

Each task area is followed by a percentage. This represents the emphasis that the exam committee has given to each section when creating and choosing questions for the NABCEP small wind installer exam.

It is the committee's hope that all who work to achieve NABCEP small wind installer certification are successful, leaving a track record of safe, productive, reliable systems that are well sited, maximize energy output, and last for decades. We also wish you many happy wind energy owners and satisfied customers—the best references any successful company could hope for. Be fruitful and multiply small wind systems!

Skills & Tools

As with any project, it is important to know in advance what skills and tools will be required to successfully complete the task. For small wind installations, specific tools and skills may vary from job to job, depending on size and type of turbine and tower, site conditions, engineering and permitting requirements, and other factors.

Listed below are the basic skills and tools you should have prior to beginning of almost any small wind-electric installation project or business, and before sitting for the NABCEP exam.

Basic Skills

- Computer: Word, Excel, www, and E-mail
- Written and verbal communication
- Reading, comprehension, and listening
- Basic math and trigonometry
- Read and interpret drawings: electrical, structural/tower, and structural/foundation
- Map interpretation: Google Earth, topographic maps, MapQuest, wind speed maps and calculators, aerial photographs, and others as appropriate
- Utility interconnection and net metering: bill interpretation, general knowledge of PURPA, net metering, and interconnection, familiarity with different types of utilities (public/private/co-op), and NEC
- Basic construction: terminology, methodology, safety and best practices, use of small tools, power tools and other equipment such as skid steer, trencher, concrete vibrators, and other excavation/foundation equipment (ability to direct a crane also highly recommended)
- Mechanical and electrical: Basic understanding of concepts, code, safety, and best practices
- Ability to think on your feet, and a willingness to part with your ego

Basic Tools

- Site Assessment: tape measure, camera, GPS, tree book, and checklist
- Safety: hard hats, lanyards and ropes, work boots, mud/concrete boots, gloves, safety glasses, appropriate clothing, first aid kit, emergency numbers, and hospital location
- Tower climbing: hard hat, climbing harness, lanyards, clips, work boots, gloves, tool bucket or belt, walkie-talkies, and ground crew
- Construction/installation: sockets and wrenches, tape measure, angle-finder, pliers, clamps, box cutters, hammer, drill, level, transit, plumb-bob, saw, screwdrivers, sledge hammer, taps, punches, come-a-longs, cable-grips, wire-tying tools, bull pins, volt meter, electrical tape, and others as listed in equipment installation manuals (also some not listed in the manuals)
- Patience and a good sense of humor

General Resources

Bartmann, Dan and Fink, Dan: Homebrew Wind Power

Chiras, Dan: Power from the Wind

Gipe, Paul: Wind Power; Renewable Energy for Home Farm and Business, 2004

Gipe, Paul: Wind Energy Basics, 2009

Home Power magazine articles (shown as: HP<issue number>-<page number>)

National Electrical Code (NEC), 2008

NEC Article 694 proposed for 2011 NEC, wind-nec.net

Piggott, Hugh: Windpower Workshop

Woofenden, Ian: Wind Power for Dummies

American Wind Energy Association: Small Wind www.awea.org

Permitting Small Wind Turbines: A Handbook www.consumerenergycenter.org

Database of State Incentives for Renewables & Efficiencies, www.dsireusa.org

U.S. Department of Energy, Energy Efficiency & Renewable Energy, www.eere.energy.gov

NREL's page on Small Wind Turbine Independent Testing, www.nrel.gov

RENEW Wisconsin's Small Wind Toolbox www.renewwisconsin.org

State Energy Conservation Office's Small Wind Systems page, www.seco.cpa.state.tx.us

Small Wind Certification Council www.smallwindcertification.org

Small Wind Tips, www.smallwindtips.com

North Carolina Wind Energy at Appalachian State University, www.wind.appstate.edu

Wind Powering America, www.windpoweringamerica.gov

Wind-Works.org: Articles, www.wind-works.org

Task Analysis

A. Conducting a Wind Energy Site Assessment (13%)

The purpose of a wind site assessment is to critically evaluate a client's site for the appropriateness of a wind energy system. A wind site assessment will specify the minimum acceptable tower height for the site based on best practices, not on what the manufacturer offers or the zoning administration would prefer to have installed. Average annual wind speed at the hub height specified is estimated. If the site has a potential wind resource and the client has realistic expectations, a number of wind turbines that fit the client's interests, abilities, goals, and budget can be recommended, along with realistic annual energy output estimates for the various choices using the best tools available.

A professional wind site assessor will be able to use and interpret online, topographic, and Google Maps, understand interconnection and zoning requirements, and be well versed in all of the small wind turbines that are reliable and available. A good site assessor will be able to realistically (and objectively) evaluate the client, the site, and the local wind resource. Further, the client should be promptly informed when a wind turbine is not a good fit due to site limitations, unrealistic expectations, or poor wind resource.

From the task analysis:

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.

1.2 Quantify the customer electrical load and energy use through review of utility bills, meter readings, measurements, and/or customer interview.

1.3 For new construction, estimate electric load based on building characteristics and electric equipment needs.

1.4 Identify opportunities incorporating energy efficient equipment or appliances, conservation, and energy management practices.

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.

1.6 Identify whether the site is suitable for a wind system.

1.7 Estimate the wind shear at a client's site based on local terrain, ground clutter, and best available wind resource map.

1.8 Determine the minimum acceptable tower height for the client's site based on terrain and obstacles.

1.9 Determine average annual wind speed at the specified tower height based on the most currently available wind maps, wind speed data, and computer programs.

1.10 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.

1.11 Specify several wind turbine system options that would be suitable for the client's energy needs as well as their technical experience and expertise.

1.12 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.

1.13 Identify one or more potential locations for a small wind energy system at a client's home site.

1.14 Diagram site plan to include tower location relative to existing homes and site features.

1.15 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.

1.16 Identify a suitable wire run from the tower base to the location of the control systems and electronics.

1.17 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.

1.18 Research utility interconnection requirements for the wind system, and how they will apply to the client.

1.19 Identify any potential zoning or building permit requirements or limitations and how they will effect the wind turbine installation.

1.20 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.

1.21 Identify any concerns about soil type or depth to bedrock for suitability of the tower foundation and/or footings.

1.22 Determine the need for any appropriate setbacks from overhead utility lines, road right-of-ways, or property lines, if applicable.

1.23 Explain wind turbine technologies and component parts, and the basic physics behind their operation.

1.24 Identify current technologies appropriate for the site and the client, for the purpose of providing several system options.

1.25 Explain the maintenance requirements for the small wind energy systems specified.

1.26 Track current pricing of small wind energy systems and components for the purpose of providing the client with rough cost estimates.

1.27 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.

1.28 Identify potential incentives, grants, and other funding sources that may be available to the client.

1.29 Identify any educational resources or opportunities that might be of help to the client.

1.30 Identify a list of next steps for the client to follow as they progress through the installation process.

Resources

Chiras:

- *Chapter 2* Understanding Wind and Wind Energy
- *Chapter 4* Wind Site Assessment

Gipe:

- *Chapter 3* Measuring the Wind
- *Chapter 4* Estimating Output – How Much to Expect
- *Chapter 6* Evaluating the Technology
- *Chapter 7* Towers
- *Chapter 13* Siting

Gipe Basics:

- *Chapter 1* Technology
- *Chapter 3* Estimating Performance
- *Chapter 4* Siting

Piggott:

- *Chapter 1* A Wind Resource

Woofenden:

- *Chapter 6* The Home Energy Assessment: Gauging Your Energy Appetite
- *Chapter 8* Determining Your Site's Wind-Energy Potential

Local tree guide for your area

Local AHJ (Authority Having Jurisdiction)/ planning commission documents as relevant

Manufacturers' and third-party training programs

Turbine manufacturers' product manuals

Resources Continued

HP40-86 Site Analysis for Wind Generators (Part 1)
HP41-60 Site Analysis for Wind Generators (Part 2)
HP86-22 The Hard Part About Wind Turbines
HP102-42 Estimating Wind Energy
HP102-70 Starting Small—Calculating Your Energy Appetite
HP115-76 Site it Right!
HP124-98 Tools of the Wind—Electric Trade
HP126-84 How Tall is Too Tall?
HP131-38 How to Buy a Wind Generator

American Council for an Energy-Efficient Economy www.aceee.org

Bing Maps, www.bing.com

Database of State Incentives for Renewables & Efficiencies, www.dsireusa.org

Google Earth, www.earth.google.com

Danish Wind Industry Association: Wind speed, wind maps, wind roses, wind energy, anemometry, and other helpful information about estimating wind resource, www.guidedtour.windpower.org

USGS Topographical Maps, www.topomaps.usgs.gov

Department of Energy, Wind Maps by State www.windpoweringamerica.gov

Google Maps, www.maps.google.com

National Climatic Data Center, www.ncdc.noaa.gov

NREL's Wind Resource Assessment Handbook www.nrel.gov

Obstruction Evaluation / Airport Airspace Analysis (OE/AAA), www.oeaaa.faa.gov

RENEW Wisconsin's Small Wind Toolbox www.renewwinsconsin.org

Wind Powering America: Link to wind maps and resource potential, www.windpoweringamerica.gov

Small Wind Turbines Wind Resource Assessment: Some Basic Issues, www.smallwindindustry.org

Small Wind Turbines Siting: Some Basic Issues, www.smallwindindustry.org

B. Working Safely With Small Wind Energy Systems (13%)

If you don't work safely around wind-electric systems, you (or someone on your crew) may not live to tell the tales. Electrical, mechanical, and live hazards may include everything from batteries to high AC voltages, and from spinning blades to hornets. Gravity is a key enemy, and can lead to falls that kill or maim people, and damage or destroy equipment and property. Identifying and understanding existing and potential hazards involved in the job are the first steps to on-the-job safety.

Once you know what the risks are, you need to learn how to avoid them. Proper use of equipment is crucial; not only will you need to know how to use installation equipment and tools, but you should also know how to use rescue and first aid gear. Communication and forethought are key skills as you will rarely, if ever, work alone on a wind-electric system.

Additionally, you will need to understand safety regulations and requirements unique to your area. Keep in mind that regulations and requirements alone will not keep you and your crew safe. It is your preparation, education, communication, training, and good practices that will keep you and those around you unharmed.

The resources cited here provide information on how to safely work with wind-electric systems. However, much of your safety education will come from experience, time on the ground, time on the tower, and from experienced mentors. Passing a test is only the beginning, and careful experience on the job must follow book learning. Staying alive and preventing injury and damage is job number one.

From the task analysis:

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.

2.2 Demonstrate safe and proper use of required tools and equipment.

2.3 Identify electrical and non-electrical personal work zone safety issues associated with wind system installations, and how to avoid them.

2.4 Demonstrate safe and proper practices in working with wind turbines, towers, and associated electrical and mechanical equipment.

2.5 Identify and implement safe and accepted practices for worker and work zone safety.

2.6 Identify and mitigate public safety issues during wind system installations.

2.7 Identify environmental considerations associated with wind system installations.

2.8 Determine if weather conditions could cause unsafe work conditions.

Resources

Gipe: *Chapter 16* Safety
Gipe Basics: *Chapter 4* Siting
Piggott: *Chapter 2* Safety
Woofenden: *Chapter 17* Safety First!

Manufacturers' installation manuals

Call 811: Know what's below, www.call811.com

Climbing Equipment Manufacturer/Supplier
wind energy kit, fall protection equipment

HP128-66 A Beginner's Guide to Tower Climbing Safety

National Lightning Safety Institute
www.lightningsafety.com

OSHA booklet on Hand and Power Tools
www.osha.gov

OSHA Construction eTool, www.osha.gov

Snap On Tools at Height, www1.snapon.com

OSHA's Fall Protection: It's a Snap! Employer Kit
employer kit, fall protection poster, fall protection info

OSHA Health and Safety Topics: Links on Hand and Power Tools, www.osha.gov

OSHA 1910, www.osha.gov

OSHA 1926, www.setonresourcecenter.com

PNNL Hoisting and Rigging Manual
hoisting and rigging manual, hostile environments, search results

Wind Power Services LLC, www.windpowerservicesllc.com

Wind-Works.org articles, www.wind-works.org

Electrical Safety Foundation International: Downloads, information, and videos on electrical safety, www.esfi.org, "Test Before you Touch" video, standards and best practices

C. Selecting a Final System Design (10%)

The options for designing a wind-electric system are numerous and can be overwhelming even for an experienced installer. New component designs and equipment manufacturers are constantly entering the market, and the number of possible system configurations continues to grow. Each installation will present a unique challenge varying with the site, the technology, the conditions, and the client's demands and expectations.

Selecting the most appropriate system will require a thorough understanding of wind turbine technology, tower and foundation design, and all of the balance of system components. It is likely that you will have to incorporate information from a number of sub-contractors, engineers, equipment suppliers, local utilities, and other service and product providers in order to design your wind-electric system and come up with a competitive bid that meets your client's expectations. It is not necessary to be an electrician or an engineer to design a wind-electric system, but it is critical that you know how to interpret one-line diagrams, read engineered blue-prints, evaluate tower and foundation plans, and know the function, requirements, limitations, and cost of every component within the system you are selecting and designing.

Off-grid applications generally have more balance of system components, and will require the understanding of other technologies besides wind, such as solar electricity, back-up generators, and batteries, to name just a few. Selecting reliable components and designing redundancy into these systems can be critical, as in many of these applications your client will be reliant on the energy produced from the system you design.

On-grid systems are not without their challenges. Selecting equipment that is code compliant, meeting utility interconnection standards, and interfacing with existing loads may require professional engineered drawings, UL and IEEE certified equipment, and third party engineering review in order for you to design your system properly, or get the permits needed to install.

Selecting a final system design often involves knowledge about, access to, and ability to interpret manufacturer or supplier product manuals & specifications. Further, knowing how to source your equipment is very important. As such, some of the most valuable resources available for this information will be manufacturer and supplier web sites and installation manuals. In addition, a good working relationship with manufacturer tech support will prove to be invaluable.

Monitoring energy production and system performance is part of any well-designed system, and should not be overlooked. If you have selected the wrong components for the job, invest in low quality equipment, lose money on the installation due to unexpected costs or endless service and maintenance, neither you nor your client will get any value from the system you have selected.

From the task analysis:

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.
- ***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, select proper earth anchors for the soil type, and calculate concrete requirements for both guyed and mono-pole structures.
- ***3.3*** For on-grid systems, determine all applicable interconnection requirements.
- ***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.
- ***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.
- ***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.
- ***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.

3.8 Identify and select major balance-of-system components required for the installation.

3.9 Identify and select appropriate system monitoring equipment, including energy monitor and wind speed indicator or data logger.

3.10 Determine the installation sequence to optimize use of time and materials.

3.11 Estimate time, materials, and equipment required for the installation, and provide an appropriate price bid.

Resources

Gipe:

- *Chapter 6* Evaluating the Technology – What Works What Doesn't
- *Chapter 9* Buying a Wind System
- *Chapter 10* Interconnection With the Utility
- *Chapter 14* Installation

Gipe Basics:

- *Chapter 5* Off the Grid
- *Chapter 6* Interconnection

Piggott:

- *Chapter 3* Rotor Design
- *Chapter 6* Mechanical Controls
- *Chapter 8* Towers

Woofenden: Part 3 Assembling Your System

Manufacturers' websites and installation manuals

Local utility interconnection requirement documents

Energy use and production data logging equipment manufacturer documentation

HP104-98 Thoughts on VAWTS
HP105-64 Wind Generator Tower Basics
HP110-10 Wind Electric Systems Simplified
HP115-110 Wind Generator Rated Power
HP127-92 Wind Power Curves
HP131-38 How to Buy a Wind Generator
HP132-128 A Better Measure Than Wind Generator Power Curves
HP 137-44 2010 Wind Generator Buyer's Guide

American Wind Energy Association's Small Wind Toolbox, www.awea.org

Database of State Incentives for Renewables & Efficiencies, www.dsireusa.org

Home Power Basics-Wind Electricity Basics
www.homepower.com

Homer Energy: software simplifies design evaluation
www.homerenergy.com

Load Analysis Spreadsheet by Benjamin Root, modified by John F. Robbins 7-1-99, www.homepower.com

Connecting to the Grid's IREC website, www.irecusa.org

Wind-NEC.com: Developing a Small Wind Article for the US 2011 National Electrical Code (NEC)
www.wind-nec.net

D. Adapting the Mechanical Design (17%)

At some point, the mechanical aspects of the system design must turn into reality. You've been through the assessment and design phase—akin to collecting 1,000 puzzle pieces—and now it's your job to make them all fit together. Exactly where will that wire run go? How deep is the bedrock? What is the frost depth at the site? What is the soil classification? Will the crane make it or will we need to stack this tower?

While much emphasis is placed on the site assessment and system design (and rightfully so), pulling together the mechanical components of the project is by far the most intense, and will draw on almost all of your skills simultaneously. You must be focused and you must pay attention to detail since even small miscalculations can lead to significant cost and/or other disastrous results.

You must be on your game; you must check and re-check your work. Whether it's a 60-foot tilt-up or a 140-foot freestanding lattice tower; whether it's a 1 kW single-phase residential or a 20 kW three-phase small commercial hook-up, it is your planning and your calculations that will determine the success or failure of the final installation.

The skills you will need in order to successfully adapt the mechanical design include reading and understanding foundation, tower, and turbine installation drawings and manuals, and general knowledge of construction equipment such as cranes, excavators, trenchers, lifts, etc. You'll also need the ability to communicate with the local planning office and engineers, an understanding of soil analysis, soil types, and how soil relates to foundation design, and the ability to create and interpret site drawings. This portion of the project encompasses project management, time management, planning, and decision-making—all skills you will need to develop to make the mechanical components you choose work together in a functional system.

From the task analysis:

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.
- ***4.2*** Identify appropriate tower location, wire run, electrical configuration, tower set backs, and maintenance considerations at the site.
- ***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.
- ***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.

Resources

Gipe:

- *Chapter 7* Towers
- *Chapter 14* Installation

Network with installers, construction and trades people, and crane operators
NEC 2008: Section 300.5 and Table 300.5
Local Authority Having Jurisdiction (AHJ)/planning commission
Locally licensed professional engineer (PE)
Tower and turbine manufacturer technical support and engineers
Turbine and tower manufacturer web sites and installation manuals

HP92-30 You Gotta Have Height
HP134-128 Wind Turbine Transmission Wire Size

Call 811: Know what's below, www.call811.com

American Wind Energy Association: Small Wind www.awea.org

In The Public Interest: How and Why to Permit for Small Wind Systems: A Guide for State and Local Governments, www.awea.org

Concrete Industry Resource Center, www.concrete.com

International Building Code/National Building Code en.wikipedia.org/wiki/International_Building_Code

Sizes.com, www.sizes.com

USDA's Natural Resources Conservation Services' Web Soil Survey, www.websoilsurvey.nrcs.usda.gov

E. Adapting the Electrical Design (8%)

When you approach the electrical portion of wind-electric system installation, you should seriously assess the situation and decide whether or not a licensed electrician is needed to perform the work, or if a licensed electrician or AHJ simply needs to inspect the installation. Electrical work is the smaller part of the job, but has the potential to be at least as, if not more dangerous, than raising a tall tilt-up tower. If you are not qualified and experienced, seek help.

Often the electrical systems you install will be designed by someone else, but it's critical that you understand the electrical components of the system and their relationship to each other in order to successfully read plans, lay out components, and properly wire them together. If something went wrong during the design phase, you need to be able to catch and correct it before installing and commissioning the system. At a minimum, you should be able to read one-line and full wiring diagrams, understanding the symbols and system design methodology completely from the drawings before ever picking up a tool.

You need to consider tower and system grounding requirements, lightning and surge suppression, safety disconnects and fusing, and system placarding as needed. If installing a grid-tied system, utility interconnect agreements need to be in place, and may have their own additional labeling or disconnect requirements. Wire run length and system configuration will be used to determine conductor sizing based on manufacturers specifications.

From the task analysis:

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.
- ***5.2*** Select appropriate conductor types and ratings for each electrical circuit in the system based on application or manufacturer specifications.
- ***5.3*** Where appropriate, determine the de-rated ampacity of system conductors based on NEC requirements.
- ***5.4*** Determine appropriate size, ratings, and locations for all system over-current and disconnect devices.
- ***5.5*** Determine the appropriate grounding system for the wind turbine and tower as specified by the equipment manufacturer, NEC, or best practices, as appropriate.
- ***5.6*** Determine appropriate size, ratings, and locations for grounding, lightning protection, surge suppression, and associated equipment as specified by the manufacturer and/or the NEC.
- ***5.7*** Determine the minimum acceptable wire size for all electrical circuits as specified by the manufacturer and/or the NEC.

Resources

Gipe:

- *Chapter 6* Evaluating the Technology
- *Chapter 10* Interconnecting With the Utility

Piggott: *Chapter 7* Electrical Controls

Local electrical inspectors & local utility
Turbine manufacturer technical support and engineers
Turbine manufacturer web sites and installation manuals

NEC 2008 and the NEC 2011 694 Revision

Developing a Small Wind Article for the US National Electrical Code (NEC), www.wind-nec.net

UL 1741 solar inverter info, www1.eere.energy.gov

HP100-116 Basic Electrical Terminology Summary
HP100-78 What the Heck? Code Book
HP100-104 & 105 National Electric Code

Database of State Incentives for Renewables & Efficiencies, www.dsireusa.org

F: Install Subsystems and Components at the Site (12%)

Once you have properly assessed the site, designed an appropriate system using quality components, and determined the proper location for those components, you must be able to safely, legally, and correctly install those components. As with other stages of the system design, siting, and installation process, there is the potential to hinder the performance of quality components through poor practices during this stage. Further, there is the potential to cause property damage, bodily injury, or even death (either during the installation process, or later during the life of the system) if unsafe installation practices are used.

Prior to performing any actual excavation, electrical, or overhead work at the site, you should have reviewed all of the plans, installation instructions, product manuals, and recommended procedures for all applicable equipment. It is important to conduct proper safety briefings, identify job-site hazards, and appoint a qualified safety officer to oversee the operations. A key item on any site is a comprehensive checklist, which will both improve efficiency and help ensure that no steps are missed.

Communication between the supervisor, equipment operators, and crewmembers is essential. Each person must be qualified to perform his or her job—all electrical and structural work should be performed by qualified and experienced people.

While the resources listed below can provide a good basis on which to build your expertise in small wind installations, they are by no means the only resources from which to draw. It is important that quality installers continue to hone their skills and expand their base of knowledge. And please remember that no written material can completely replace practical experience and common sense. A successful installation is measured by both its performance and its safety. Neither one of these factors can be ignored.

From the task analysis:

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.
- ***6.2*** Utilize a checklist to assure that all aspects of the installation have been performed.
- ***6.3*** Implement all applicable work zone safety and environmental protection measures and protocols during installation.
- ***6.4*** Utilize appropriate math skills to lay out the tower and foundation.
- ***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.
- ***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.
- ***6.7*** Assemble the tower and wind turbine as specified by the appropriate equipment manufacturers or suppliers.
- ***6.8*** For crane installations, utilize crane operator signals and protocol, and be able to communicate with the crane operator during the tower and turbine lift.
- ***6.9*** For tilt-up tower installations, implement the installation process and safety considerations unique to the equipment and situation.
- ***6.10*** Determine the installation process, equipment, and safety considerations unique to stacking tower installations.
- ***6.11*** Measure and check that the tower is straight and plumb.
- ***6.12*** Check fasteners and guy cables for proper tension using appropriate standards and or the manufacturer recommendations when provided.
- ***6.13*** Install the wiring for the turbine, tower, and wire run, disconnect switches, and over-current protection devices.
- ***6.14*** Complete the final assembly and installation of all electrical components, inverters, control-

lers, 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.

6.15 Label, install, and terminate electrical wiring, verify proper connections, voltages, and phase/polarity relationships.

6.16 Verify continuity of the grounding system.

6.17 Program, adjust, and configure inverters and controllers for desired set points and operating modes, as appropriate.

Resources

Chiras: *Chapter 6* Tower and Tower Installation

Gipe:

- *Chapter 7* Towers
- *Chapter 14* Installation

Piggott: *Chapter 8* Towers

Woofenden: Part 3 Assembling Your System

Local electrical inspectors or Authority Having Jurisdiction (AHJ) and local utility

Turbine and tower manufacturer technical support and engineers

Turbine and tower manufacturer web sites and installation manuals

Manufacturers' and third party training programs

NEC 2008

HP99-118 What the Heck? Gin Pole

Concrete Industry Resource Center, www.concrete.com

FD Lake Construction and Industrial Supplies
www.fdlake.com

PNNL Hoisting and Rigging Manual
hoisting and rigging manual, hostile environments, search results

Safety & Health Electric Power Generation, Transmission and Distribution-General Industry Standard
osha.gov (Section 1910.269)—just be aware that this exists

Developing a Small Wind Article for the US National Electrical Code (NEC), www.wind-nec.net

Crane signals and other crane information
www.womanoperator.org

G. Performing a System Checkout and Inspection (13%)

After all the work is done, the site assessed and the turbine sited, the foundation built, wire run, and components installed, you'd like to take a deep breath and call the job done. Bet there will always be a series of scene assessments, double checks, and checklists that will make the difference between a successful job and the beginning of a series of operational and maintenance issues—each costly and needless.

It is absolutely critical that you refer to all manufacturers manuals and complete their commissioning checklists. These will include everything from verifying proper torque on all bolt connections, proper on and off load operation of the turbine, testing for proper operation of pitch or furling functions, mechanical or electromagnetic braking systems, and proper battery charging, grid tie, pumping, or heating operation.

Other tasks at the end of the project include registration of the turbine with the manufacturer for warranty purposes, transferring manuals and other manufacturers' documentation to the system owner, and instructing them in proper operation of the system. Be sure to go over the normal modes of operation, such as what the machines sounds like in normal operation and when it pitches or furls, or when the brake engages, and how much movement at the top of the tower is normal or abnormal. People often won't know what to expect, especially if your project is their first small

wind experience. You can help make their life as the consumer and your life as the installer and maintenance service provider much easier and happier.

From the task analysis:

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.
- ***7.2*** Visually check the mechanical installation for structural integrity.
- ***7.3*** Verify the electrical installation for proper wiring practice, polarity or phase relationships, grounding, and integrity of terminations.
- ***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.
- ***7.5*** Activate the system in proper start-up sequence and verify overall system functionality.
- ***7.6*** Provide an electrical diagram for the system, and explain it to the owner or operator of the wind system.
- ***7.7*** Demonstrate and post in writing the procedures for connecting and disconnecting the system and equipment from all electrical sources.
- ***7.8*** Demonstrate and post in writing shut-down procedures for use by the owner or operator, and emergency personnel if required.
- ***7.9*** Identify and verify all required markings and labels for the system and equipment.
- ***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.

- ***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.
- ***7.12*** Observe and listen to the turbine and equipment to determine that the system is operating correctly.
- ***7.13*** Check fasteners and guy cables for proper tension using appropriate standards and or the manufacturer recommendations when provided.
- ***7.14*** Secure guy cable turnbuckles with "figure 8" safety loops.

Resources

Piggott: *Chapter 8* Towers

Gipe: *Chapter 14* Installation

Turbine and tower manufacturers' manuals and documentation

NEC 2008

Developing a Small Wind Article for the US National Electrical Code (NEC), www.wind-nec.net

Section H: Maintain and Troubleshoot (13%)

Wind turbines are subjected to intense environmental conditions, and require regular inspections and maintenance. Frequency of inspections and level of maintenance will vary by turbine, tower type, manufacturer, site characteristics, and other factors. Some will require full hands-on maintenance twice per year, and others may only require a visit once per year. But no matter how you slice it, all wind turbines require maintenance. With regular servicing and timely maintenance, problems can often be detected before they become expensive or dangerous.

As an installer, it is just as important for you to provide follow-up service, maintenance, information, and records to your customers as it is for you to do a good job on the installation itself. Remember that the turbine

owner has invested quite a lot of his/her hard-earned money (and possibly sweat-equity) into the project, and deserves to have a wind energy system that performs as promised. The more adept you are at troubleshooting, the easier it will be for you to provide affective, timely maintenance. This makes for happy turbine owners, and happy turbine owners give referrals.

As technology matures and new equipment becomes available, you will need to update your training. And as you install different types of systems, your knowledge base will grow. For maintenance and troubleshooting, you will often rely heavily on the manufacturers' installation and owner's manuals. And there are some basic skills, tools and resources (listed below) that you should have under your belt.

We encourage you to draw on the knowledge and experience of other installers and industry professionals. Some of the industry's best small wind installers are where they are today because they understand that it's not really about knowing all there is to know. It's about knowing where to find the information you need and when to ask for help—your colleagues will be your lifeline.

From the task analysis:

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.

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.

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.

8.4 Perform mechanical and electrical diagnostic procedures and interpret results.

8.5 Identify performance issues and safety concerns, and implement corrective measures.

8.6 Verify and demonstrate complete functionality and performance of the system, including start-up, shut-down, normal operation, and emergency or bypass operation.

8.7 Compile and maintain records of system maintenance and repairs, and provide a copy to the owner or operator.

Resources

Gipe:

- *Chapter 14* Installation
- *Chapter 15* Operating and Maintaining a Small Wind System
- *Chapter 16* Safety

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HP 98-76 Flooded Lead-Acid Battery Maintenance
HP 134-74 Troubleshooting Small Wind Systems
HP 135-98 Wind Electric Systems Maintenance
HP 136-92 Noise and Heat

Turbine and tower manufacturer technical support and engineers

Turbine and tower manufacturer web sites and installation manuals

Battery Council International: Source of battery-related information, www.batterycouncil.org

Wind turbine blade and tower icing
en.wikipedia.org/wiki/Hard_rime

Fluke Electronics, us.fluke.com

Preventing Fatalities, www.osha.gov

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