NABCEP

Small Wind **Associate** Learning Objectives

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Introduction:

The following document outlines the Learning Objectives that NABCEP's subject matter experts (SME) have identified as appropriate and relevant for Small Wind Associate education and training programs. The Learning Objectives were developed and validated through broad consultation with the small wind community, including representatives from small wind manufacturers, distributors, installers, and educators.

It is intended that this document will enable educators to develop curriculum that will prepare students for careers in the small wind industry. NABCEP has developed a Small Wind Associate Exam that may be offered to students who complete programs based on these Learning Objectives through a Registered Associate Exam Provider or who document 6 months of employment in the renewable energy industry. Achieving a passing score on the NABCEP Small Wind Associate Exam will indicate that the candidate has demonstrated basic knowledge of the fundamental principals of the application, installation, design and operation of small wind energy systems in North America.

Exam Blueprint:

In addition to developing the Learning Objectives, the committee prepared an examination blueprint. The Small Wind Associate Exam Committee will use the following blueprint to develop the structure and content of the exam.

Exam Specifications	**Percent of Exam**	**# Exam items**
1. Fundamentals of Electricity	7%	4
2. Applications and End Uses	5%	3
3. Fundamentals of Small Wind Turbines (including system components and science and theory)	15%	9
4. Towers, Foundations, and Installation Considerations	13%	8
5. Resource Assessment	15%	9
6. Site Assessment	13%	8
7. System Sizing Principles and Economics	8%-9%	5
8. Operation, Maintenance, and Troubleshooting	8%-9%	5
9. Safety and Best Practices	10%	6
10. Impacts and Challenges of Small Wind	5%	3
TOTAL	**100%**	**60**

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Knowledge Content Domains and Learning Objectives:

Knowledge Content Domains	# of LOs
1. Fundamentals of Electricity	9
2. Applications and End Uses	4
3. Fundamentals of Small Wind Turbines	
3a. System components (6)	14
3b. Science and theory (8)	
4. Towers, Foundations, and Installation Considerations	10
5. Resource Assessment	15
6. Site Assessment	11
7. System Sizing Principles and Economics	8
8. Operation, Maintenance, and Troubleshooting	7
9. Safety and Best Practices	10
10. Impacts and Challenges of Small Wind	6
TOTAL	**94**

The Learning Objectives are categorized regarding their importance to mastery of the knowledge in the content domain as Critical, Important, or Useful. The number of Learning Objectives that fell into each Importance category is shown below.

Number of LOs in Each Importance Category

Level	LOs
Critical	33
Important	42
Useful	19
TOTAL	**94**

The Learning Objectives are also categorized with reference to the difficulty for students to acquire the underlying knowledge supporting each learning objective. The categories included Not difficult, Somewhat difficult, or Very difficult. The number of learning objectives in each Difficulty category is shown in below.

Number of LOs in Each Difficulty Category

Level	LOs
Not difficult	18
Somewhat difficult	72
Very difficult	4
TOTAL	**94**

Small Wind Associate Learning Objectives:

The final list of 94 Small Wind Associate Learning Objectives, together with the Importance and Difficulty category of each, is shown below.

NABCEP Small Wind Knowledge Content Areas and Learning Objectives

1. Fundamentals of Electricity

		Importance	Difficulty
101	Differentiate between single phase/split phase, and three phase AC power, and differentiate from wild AC.	Critical	Somewhat
102	Identify nominal AC/DC system voltages (including but not limited to 24, 48, 120, 208, 240, and 480).	Critical	Somewhat
103	Identify amp rating and service voltage on a service panel.	Critical	Not
104	Read and interpret an electrical kilowatt hour meter.	Critical	Not
105	Read and interpret an electrical utility bill in order to determine average load usage, (including but not limited to energy usage, system demand, customer demand, and time of use rates).	Critical	Not
106	Complete a load analysis process used for sizing off grid systems.	Important	Very
107	Explain the fundamentals of electric utility distribution systems that service buildings and facilities, including generation and transmission.	Useful	Somewhat
108	Recognize the importance of the National Electrical Code and how it applies to small wind systems.	Critical	Somewhat
109	Discuss proper safety procedures needed for handling and installing small wind electrical equipment.	Critical	Somewhat

2. Applications and End Uses

201	Describe various end uses of wind energy technology (including but not limited to electrical generation for purposes of load reduction, remote and stand-alone loads, telecommunications, water pumping, heating, and transportation).	Useful	Not
202	Describe various market segments, such as residential, agricultural, commercial, industrial, educational, as well as village, community, and utility scale wind power.	Useful	Not
203	Describe the features, benefits, and limitations of off-grid and grid-tied systems, small wind/photovoltaic hybrid systems, and systems with and without energy storage.	Important	Somewhat
204	Define distributed generation as it applies to small wind.	Useful	Somewhat

3. Fundamentals of Small Wind Turbines

System components		Importance	Difficulty
301	Describe system components (such as rotors, generators, and over-speed protection devices) and their functions.	Critical	Somewhat
302	Compare wind turbine designs and discuss benefits and limitations of each, including: • upwind versus downwind • vertical axis versus horizontal axis • fixed versus variable pitch blades • induction versus wild AC variable speed generators/alternators • lift versus drag • direct drive versus gear driven • types of rotor overspeed control	Critical	Somewhat
303	Identify major subsystems and components (for example, slip rings and brushes, yaw mechanisms, safety switches, and shut down mechanisms).	Critical	Somewhat
304	Describe the purpose and function of the primary system power processing equipment, including but not limited to inverters, controllers, and diversion loads, as they relate to various system configurations.	Critical	Somewhat
305	Identify the components unique to off-grid systems, including but not limited to batteries, charge controllers, and hybrid system equipment.	Critical	Somewhat
306	Explain the pros and cons of maximum power point tracking controllers with regard to system energy production (including but not limited to increased system complexity. lifespan, and cost).	Useful	Very
Science and theory			
307	Explain how a turbine converts wind energy into electrical energy.	Critical	Not
308	Explain the significance of rotor swept area as it relates to energy capture and conversion.	Critical	Not
309	Describe basic concepts of aerodynamics related to rotor operation, including: • Lift and drag • Blade configuration and rotor solidity • Twist and taper • Tip speed ratio • Stall regulation	Useful	Somewhat
310	Explain the special considerations of 2-bladed rotors.	Useful	Somewhat
311	Describe potential technology issues related to building integrated wind turbines and roof mounted turbines.	Important	Somewhat
312	Explain the purpose and operation of various rotor over-speed protection devices.	Critical	Somewhat
313	Compare the AWEA Small Wind Safety and Performance Standard (power curves, rated power, rated wind speed, rated sound, and annual energy output) against manufacturers' published specifications.	Important	Somewhat
314	Explain how a power curve and an energy production estimate are created.	Important	Somewhat

4. Towers, Foundations, and Installation Considerations

		Importance	Difficulty
401	Describe the five basic tower types (free standing lattice, guyed lattice, monopole, guyed tilt-up, and monopole tilt-up) and the advantages and limitations of each.	Critical	Not
402	Compare materials, cost, maintenance requirements, footprints, assembly, and turbine accessibility of each tower type.	Important	Somewhat
403	Explain the concepts underlying the appropriate pairing of specific towers for specific turbines, taking into consideration factors such as loading requirements, rotor swept area, and harmonics.	Important	Somewhat
404	Explain the concepts underlying the design of tower foundations, taking into consideration factors such as tower height, turbine and wind loading, and soil type.	Important	Somewhat
405	Explain lightning issues and describe various mitigation methods (including but not limited to tower versus component grounding, lightning arrestors, and surge arrestors).	Important	Somewhat
406	Recognize when a soil analysis is required to properly specify, configure, and engineer a suitable foundation or footings for the tower.	Important	Somewhat
407	Describe how tower and turbine system space requirements may affect site access and system installation.	Important	Somewhat
408	Describe the advantages and limitations of various installation methods, including crane, tilt-up, and gin pole stacking.	Important	Somewhat
409	Describe how site conditions (including but not limited to topography, soil conditions, and existing infrastructure) affect installation method.	Important	Somewhat
410	Explain the importance of identifying a correct pick point when lifting a tower freestanding lattice, monopole, guyed with a crane, and the ramifications of using an incorrect pick point.	Useful	Somewhat

5. Resource Assessment

501	Describe the purpose and function of anemometers, wind vanes, and data loggers, and when and why met towers are used.	Important	Not
502	Calculate the theoretical power available in the wind, given swept area, air density, and wind speed.	Important	Somewhat
503	Describe the effect of altitude and temperature on air density.	Useful	Somewhat
504	Describe a wind profile and what it represents.	Useful	Somewhat
505	Recognize the purpose and function of a wind speed distribution curve, and explain its relationship to a wind turbine's power curve.	Important	Somewhat
506	Define wind shear and describe how it affects wind speed at different heights.	Important	Somewhat
507	Distinguish between laminar and turbulent air flow.	Useful	Somewhat

Continued

5. Resource Assessment Continued

		Importance	Difficulty
508	Define turbulence and its sources, and describe its effect on turbine output.	Important	Somewhat
509	Identify wind resource estimation tools, such as spreadsheets, calculators, and wind maps.	Important	Somewhat
510	Explain the data and assumptions used to create wind estimation tools and the limitations of each tool.	Useful	Somewhat
511	Read and interpret a wind map.	Important	Somewhat
512	Describe a wind rose, and explain the difference between prevailing wind direction and prevailing energy direction.	Important	Somewhat
513	Explain the relevance of prevailing wind energy direction to siting the tower and turbine.	Critical	Somewhat
514	Describe diurnal, seasonal, and annual fluctuations in wind and their significance to off-grid and on-grid wind systems.	Useful	Somewhat
515	Utilize wind speed calculator(s) to determine how input variables affect expected wind speed at various hub heights.	Important	Somewhat

6. Site Assessment

601	Explain the impact of turbulence, wind shear, and displacement height on siting.	Important	Somewhat
602	Estimate height of obstacles.	Important	Not
603	Explain flagging and its use and limitations.	Useful	Not
604	Identify relevant setbacks that may affect potential tower locations, considering site characteristics such as overhead utility lines, right of ways, and property boundaries.	Critical	Somewhat
605	Determine location and minimum acceptable height of a wind turbine tower based on impact of trees, buildings, terrain, ground clutter, and topography.	Critical	Somewhat
606	Calculate displacement height and incorporate it into wind speed and energy output calculations.	Important	Somewhat
607	Identify elements of a site plan (including but not limited to tower location, obstructions, property infrastructure, and property lines).	Critical	Somewhat
608	Understand FAA regulations and use of the FAA	Useful	Not
609	Utilize energy output calculator(s) to determine how input variables affect energy production.	Important	Somewhat
610	Locate resources regarding interconnection requirements (including but not limited to interconnection applications, inspections, and agreements).	Important	Somewhat
611	Describe the potential siting issues related to building integrated wind turbines and roof mounted turbines.	Important	Somewhat

7. System Sizing Principles and Economics

		Importance	Difficulty
701	Discuss the importance of conservation and energy efficiency as they relate to system applications.	Useful	Not
702	Quantify the customer electrical load and energy use through review of utility bills, meter readings, measurements, and/or customer interviews.	Important	Somewhat
703	Explain why average monthly wind speeds are used to size off-grid systems, and average annual wind speeds are used to size grid-tied systems.	Important	Somewhat
704	Compare the inputs (including but not limited to wind resources, electrical load, budget, and expectations) required for sizing grid-tied and off-grid systems, and small wind/photovoltaic hybrid systems.	Important	Somewhat
705	Identify resources to locate available incentives and utility rate structures (such as on peak/off peak, demand charges, net metering, and time of use metering).	Important	Somewhat
706	Identify the factors that affect the economic benefits and limitations of various system types and configurations, taking into consideration eligibility for incentives, available utility feed-in tariffs, and net metering policies.	Important	Somewhat
707	Identify situations that might render wind energy a non-viable option for a customer.	Critical	Somewhat
708	Compare and contrast renewable energy options to small wind, discussing the costs and benefits of each source.	Useful	Somewhat

8. Operation, Maintenance, and Troubleshooting

801	Describe the purpose and function of performance measurement equipment, including but not limited to kilowatt hour meters, data loggers, and battery monitors.	Important	Somewhat
802	Discuss the importance of documentation and record-keeping procedures related to operation, maintenance, and troubleshooting.	Important	Not
803	Describe the purpose and function of basic electrical test equipment, including but not limited to voltmeters, ammeters, ohmmeters, and multimeters.	Important	Somewhat
804	Discuss basic troubleshooting procedures (recognize a problem, observe the symptoms, diagnose the cause, and take corrective actions) as they apply to the main system and subsystems.	Critical	Very
805	Identify the issues that might cause actual output to be different from estimated output (including but not limited to system design flaws, manufacturers' marketing, component failures, improper wind resource assessment and/or siting, installation, and/or maintenance).	Important	Very
806	Describe typical system inspection and maintenance intervals and activities that may be applicable to small wind turbines and towers (including but not limited to electrical, mechanical, hydraulic and pneumatic equipment).	Important	Somewhat
807	Describe maintenance requirements for different tower types (including but not limited to cranes and climbing, manual tilt-down, and hydraulic tilt down).	Important	Somewhat

9. Safety and Best Practices

		Importance	Difficulty
901	List the proper sequence and describe the typical tasks required for maintenance and inspection of the foundation, tower, and turbine.	Critical	Somewhat
902	Describe the tasks required for inspection of the electrical components and wiring connections for both grid-tied and off-grid systems.	Critical	Somewhat
903	Discuss proper procedures for operating and maintaining different types of systems (including but not limited to start-up and shut-down procedures, and tower tilting).	Critical	Somewhat
904	Describe the purpose and application of OSHA to small wind.	Important	Somewhat
905	Discuss safety considerations unique to each tower type.	Critical	Somewhat
906	Describe basic personal fall protection equipment (PFPE) and practices as they pertain to climbing safety.	Critical	Somewhat
907	Determine when weather conditions could cause unsafe work conditions.	Critical	Not
908	Identify worker, work zone, and public safety considerations and accepted practices associated with wind system installation and maintenance, including personal protective equipment (PPE), tool use, hoisting and rigging safety, and tilt-up tower safety.	Critical	Somewhat
909	Recognize principal electrical safety hazards associated with systems, including electrical shock and arc flash.	Critical	Somewhat
910	Recognize when systems may need to be locked out/tagged out and when power may be necessary for testing, troubleshooting, and maintenance procedures.	Critical	Somewhat

10. Impacts and Challenges of Small Wind

1001	Describe the environmental, societal, and economic benefits of small wind compared to all other energy sources.	Useful	Not
1002	Recognize that there may be site-specific environmental considerations regarding sensitive and protected areas, and that governmental agencies may have jurisdiction over these areas.	Useful	Somewhat
1003	Discuss the effect of local permitting and zoning regulations on the installation of small wind systems.	Critical	Somewhat
1004	Discuss myths and misconceptions about the impact of small wind systems (including but not limited to ice throw, shadow flicker, impacts on wildlife, vibration and sound, and perceived health impacts).	Important	Not
1005	Compare and contrast tested and untested/unverified devices and products in the small wind market (including but not limited to unconventional rotor designs, rooftop and building integrated turbines).	Critical	Somewhat
1006	Identify and use industry-supported and/or third-party resources, including Small Wind Certification Council certification, that provide data regarding systems and performance.	Important	Not

Appendix I – Prerequisites:

The subject matter experts that prepared the Small Wind Associate Learning Objectives strongly recommend that all students possess some knowledge of electricity. To that end they recommend that a basic electricity course be a prerequisite to any course that is intended to cover the Small Wind Associate Learning Objectives. At the very minimum any prerequisite course should cover the Learning Objectives outlined below. If a prerequisite course is not to be required educators should take careful note to include the following Learning Objectives in their course curriculum.

Learning Objectives Recommended to be Moved to Prerequisite Basic Electricity Course

Small Wind Knowledge Content Areas and Learning Objectives		Importance Difficulty	Recommended Prerequisites
101	Define voltage, current, power, energy, and resistance.	Critical	Not
102	Use and read a multimeter.	Critical	Not
103	Define direct current (DC) and alternating current (AC).	Critical	Not
105	Discuss proper safety procedures needed for handling and installing electrical equipment	Critical	Somewhat
113	Discuss proper safety procedures needed for handling and installing electrical equipment	Critical	Somewhat

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