

**Site Selection and Factors
Influencing Small Wind
Systems' Energy Output**

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CWEC Small Wind Workshop
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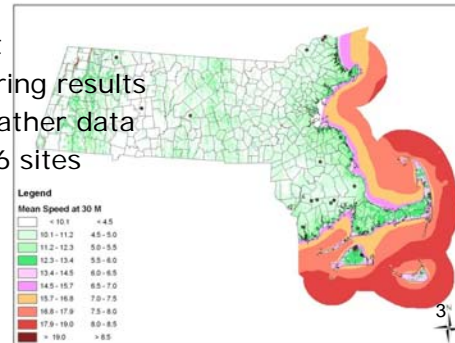
Cadmus' Clean Energy Practice

- Technical reviews/inspections of renewable energy systems and designs
- Performance tracking and monitoring
- Technology testing and evaluation
- Program design, support, and evaluation
- Project feasibility studies
- Marketing and outreach

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Small Wind System Performance: The Massachusetts Example

- 36 small wind turbines installed
- 21 systems analyzed
- Data collected
 - Monthly Energy Output
 - Limited on-site monitoring results
 - Regional long-term weather data
 - Met tower data from 16 sites

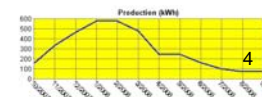


System Performance Tracking in Massachusetts

Production Tracking System (PTS)

- 800+ systems reporting
 - Automated (e.g. Fatspaniel)
 - Manual
- Links with any DAS provider
- Customizable

Selected System	
System Name:	D. Hanson - 157ND
System ID:	192-85714-00844
Capacity:	5,000 kW
Production Month	Production (kWh)
October 2007	332
November 2007	332
December 2007	487
January 2008	379
February 2008	379
March 2008	479
April 2008	244
May 2008	244
June 2008	183
July 2008	102
August 2008	73
September 2008	78

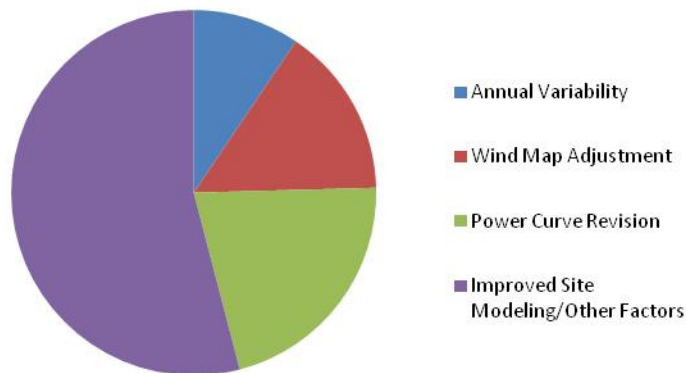


Small Wind Turbine Performance

- Annual energy output 29% of expected for 21 systems
- No site type, system, or installer is meeting energy output estimates
- Available site/system analysis methods produce unrealistic results

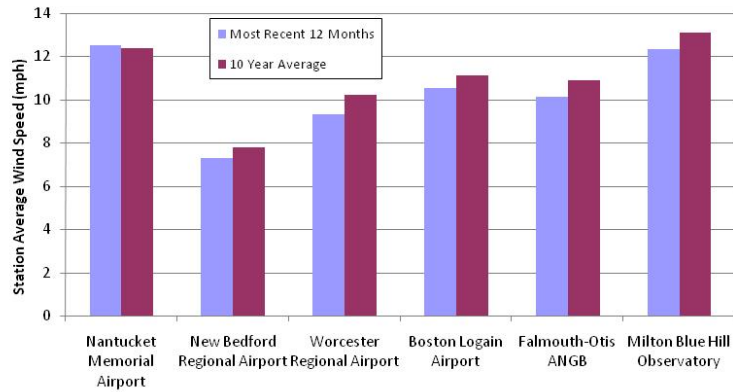
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Factors Influencing Small Wind System Output



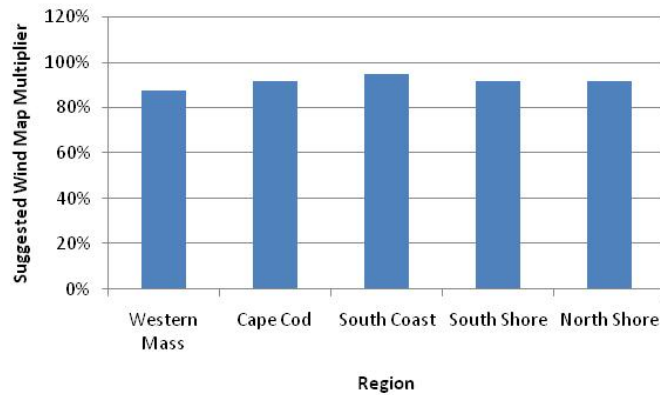
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Annual Wind Speed Variability



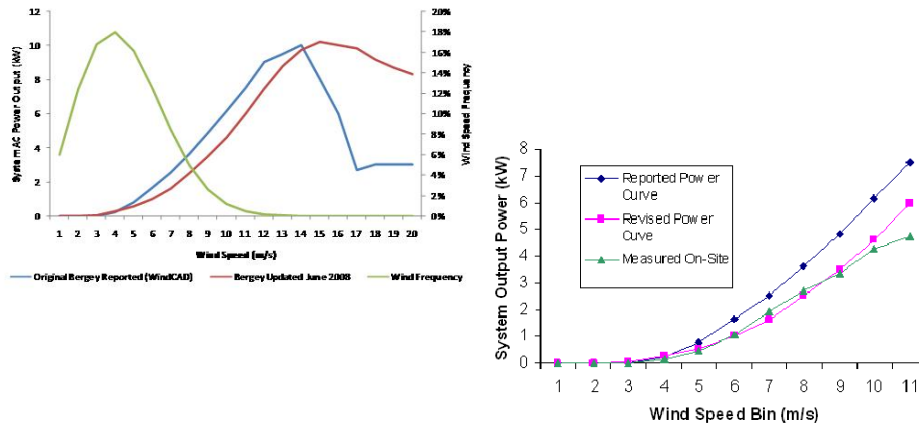
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Wind Map Validation Results



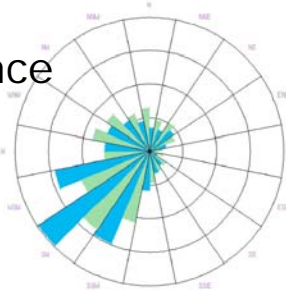
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Inaccurate Power Curves



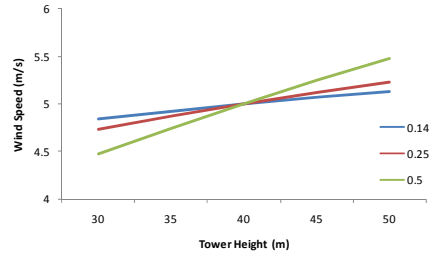
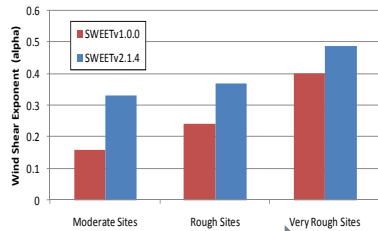
Impacts of Site Conditions

- Wind shear/roughness
- Obstructions
- Directional dependence



■ Percent of Total Wind Energy (kWh/yr)
 ■ Percent of Total Time
 Center Point = 0%
 Each Outer Circle = +5%

Wind Shear Impacts Wind Speed and Tower Height

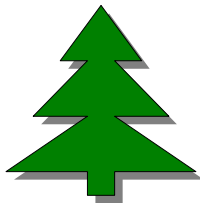


How we adjust wind shear from 50m to 30m can change wind speed estimate by ~20%

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Obstructions-Height and Effective Ground Level

50 ft Obstruction



+ 100 ft Tower



= 50 ft Tower!



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An Example of Site Impact



Site #1: OpenLand Farms
 Annual 30m Wind Spd: 4.5 m/s
 Tower Height: 100 ft
 Annual kWh: 3,332 kWh

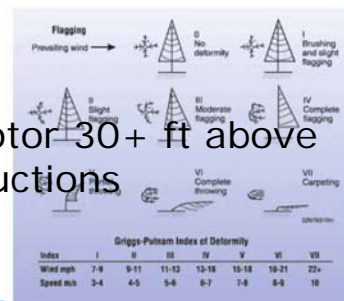


Site #2: Tall Trees Lane
 Annual 30m Wind Spd: 4.7 m/s
 Tower Height: 100 ft
 Annual kWh: 1,268 kWh

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Characteristics of a Good Site

- Open fetch in prevailing wind direction
- Minimal obstructions
- Smooth terrain
- Windward slope
- Flagged vegetation
- Minimum tower gets rotor 30+ ft above any surrounding obstructions

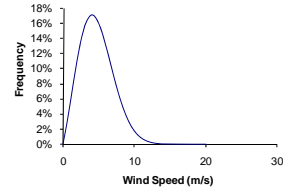


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Estimating Annual Energy Output

Key Variables

- Average wind speed
- Probability distribution
- Wind rose
- Terrain type
- Obstacle height and type
- Reliable turbine data



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The Small Wind Energy Estimator Tool (SWEET)

Step 1: Enter the information about your proposed wind energy system in the green boxes.

General Information
 Name of Person Completing Form: [Green Box]
 Application Name: [Green Box]
 Applicant Email Address: [Green Box]
 Site Address: [Green Box]

System Information
 Turbine: [Green Box]
 Tower Height: [Green Box]
 Tower Type: [Green Box]

Site and Wind Resource Information
 Latitude: [Green Box]
 Longitude: [Green Box]
 Average Annual Wind Speed: [Green Box]
 Average Annual Wind Speed: [Green Box]
 Average Annual Wind Speed: [Green Box]
 Elevation: [Green Box]
 Distance to Nearest Power Line: [Green Box]
 Location of Tower: [Green Box]

Wind Direction: [Green Box]

Frequency (%)	Terrain	Height of Nearest Obstacle (Feet)	Obstacle Type
1.0%	Medium	10	Vegetation
2.0%	Medium	10	Vegetation
3.0%	Medium	10	Vegetation
4.0%	Medium	10	Vegetation
5.0%	Medium	10	Vegetation
6.0%	Medium	10	Vegetation
7.0%	Medium	10	Vegetation
8.0%	Medium	10	Vegetation
9.0%	Medium	10	Vegetation
10.0%	Medium	10	Vegetation
11.0%	Medium	10	Vegetation
12.0%	Medium	10	Vegetation
13.0%	Medium	10	Vegetation
14.0%	Medium	10	Vegetation
15.0%	Medium	10	Vegetation
16.0%	Medium	10	Vegetation
17.0%	Medium	10	Vegetation
18.0%	Medium	10	Vegetation

Site Weibull Shape Factor: 2.22
 Conversion/Equipment Losses: 1.00
 Voltage Drop: 0.00
 Standby Power Losses: 0.00
 Availability: 0.95
 Miscellaneous Losses: 0.00

Wind Project System Summary Report

Customer Name: Green State
 System Designer: [Green Box]
 Report Date: 10/26/2008

Site Information
 Latitude: 41.06
 Longitude: -70.22
 Average Annual Wind Speed: 6.10 m/s
 Average Annual Wind Speed: 13.64 mph
 Average Obstacle Height: 28 Feet
 Average Obstacle Height: 85.30 Feet
 Conversion Losses: 1.00
 Misc. Losses: 0.00
 Weibull K Factor: 2.22

Site Wind Rose (9% per direction)
 Wind Rose (9% per direction)

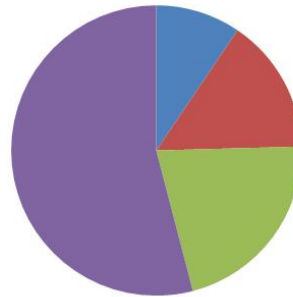
System Information
 Turbine Manufacturer: SWEET
 Turbine Model: SWEET
 Tower Height: 128 Feet
 Rated Wind Speed: 11.6 m/s

Annual Production Estimates
 Average Annual Energy Output: 12,041 kWh/yr
 Conversion/Equipment Losses: 0.00%
 Voltage Drop: 0.00%
 Standby Power Losses: 0.00%
 Availability: 0.95%
 Miscellaneous Losses: 0.00%
 Production Increase in Proposed System: 100%

Massachusetts Technology Collaborative logo.

A Recipe for Successful Small Wind Programs

Good Sites
+
Good Equipment
+
Supportive Incentives
+
Feedback
=
Successful Small Wind Program



■ Annual Variability
■ Wind Map Adjustment
■ Power Curve Revision
■ Improved Site Modeling/Other Factors

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Program Options: Good Siting

- Pre certification
- Installer training
- Screening criteria
- Comprehensive estimating methods

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Program Options: Good Equipment

- Eligible Equipment List
- SWCC listing (when ready)
- Basic testing requirements for non listed systems to prove reliability
- In Field power curve verification



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Program Options: Incentives

- Capacity based
 - Administratively simple
 - Risk of high \$/kWh produced
- Production based
 - Does not help with upfront cost
 - Fixed \$/kWh produced = low risk
- Hybrid approaches
 - Capacity based, with adders
 - Split payment between capacity/production

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Program Options: Feedback

Measured Parameters

- Energy output
- Wind resource
- Downtime
- Environmental

Collect/analyze data to drive program development

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Thank You

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