#### **TOWN OF DARTMOUTH**

# REQUEST FOR PROPOSALS

# PURCHASE OF RENEWABLE ENERGY IN DARTMOUTH, MASSACHUSETTS

August 23, 2011

# 1. Introduction and Background

The Town of Dartmouth ("Town") acting through its Executive Administrator hereby issues this Request for Proposals ("RFP") to solicit proposals and evaluate competing offers from qualified renewable energy developers (hereinafter the "Proponents") who will sell to the Town to renewable energy in accordance with the attached Design and Performance Specification ("System") with onsite electricity generation from a site in the Town of Dartmouth. The Town intends to select and enter into a power purchase agreement with the most highly qualified provider per the evaluation criteria herein.

The power purchase agreement will be for a minimum of 20 years and a maximum of 30 years. Electricity generated from this project will be delivered to a suitable electrical grid interconnection point. The Proponent will be responsible for the interconnection study, permit, and any subsequent interconnection costs as well as development of the energy renewable system. The Proponent will retain all Renewable Energy Certificates (SREC), Environmental Credits, Tax Credits, and other credits or grants derived from the renewable energy project. The Town proposes to purchase the renewable energy from the project under a Power Purchase Agreement (PPA) for Net Metering purposes.

#### 2. Contact Person

All communication regarding this RFP must be made in writing and directed to:

David G. Cressman Executive Administrator 400 Slocum Road Dartmouth, MA 02747

Email: cressmandg@town.dartmouth.ma.us

### 3. Mandatory Pre-Proposal Conference and Site Tour

There will be one mandatory Pre-Proposal Conference will be held at 10:30 a.m. on September 7, 2011 at the Dartmouth Town Hall, in Room 304, 400 Slocum Road, Dartmouth, MA, 02747. All prospective proponents must attend.

Note: Questions posed verbally at the pre-proposal conference must be submitted in writing to the Town in electronic format within two (2) calendar days after the pre-proposal conference. The Town will issue a post conference addendum reciting each question and its response. Only the information contained in that addendum shall be relied upon when submitting a proposal.

### Final Inquiry Date:

All questions and inquiries concerning this RFP should be submitted in writing no later than September 23, 2011. Email preferred method of contact cressmandg@town.dartmouth.ma.us.

Inquires will not be answered directly. The Town will issue the addendum via email response to all in attendance at the Pre-Proposal Conference by September 30, 2011.

\*\* The Town reserves to amend this RFP based on questions and issues raised prior to and at the Pre-Proposal Conference.

### 4. Performance Bond Submittal Requirements

As part of the contract, the selected proponent will be required to provide a performance bond in the amount of \$250,000 payable to the Town of Dartmouth in the event the successful proponent is unable to procure a fully operational wind energy generating facility in accordance with and the timelines agreed upon in the power purchase agreement. Proponents shall submit proof as part of their proposal of an ability to attain such a bond from a reliable and reputable firm and said proof shall be signed by an officer at the bonding company authorized to provide such a bond. This bond shall be released by the Town upon successful startup and the generation of wind energy from the facility.

A separate bond in the amount of \$600,000 payable to the Town of Dartmouth for the decommissioning of the facility shall be posted during the operating phase.

### 5. Disclosure of Confidential or Proprietary Information

Proponents must specifically identify those portions of their proposals, if any, which they believe contain confidential or proprietary information or trade secrets. They must provide justification why such materials should not be disclosed under a public records request, including the proper citations to the law supporting the exclusion from the mandatory disclosure under the Public Records Law of Massachusetts, M.G.L. Chapter 66.

#### 6. Real Time Monitoring

Web-based monitoring will be developed and maintained by the Proponent to display the benefits of the renewable energy generating facility and to be a public education tool. The web site shall be linked to the Town of Dartmouth and available for public access through the Town's web site. The monitoring will include instantaneous kW; daily kWh generation; kW and kWh output on a monthly basis; and actual year-to-date and lifetime kWh.

#### 7. Incurred Expenses

The Town is <u>not responsible</u> for any expenses that Proponents may incur in preparing and submitting proposals. All materials and documents submitted in response to this solicitation become the property of the Towns and will not be returned.

#### 8. Conditions

Each Proponent shall become fully acquainted with conditions relating to the scope and performance of the work under the contract.

The Proponent shall make a determination as to conditions and shall assume all development risk and responsibility and shall complete the work in and under conditions they may encounter or create in accordance with the timelines established in **Section 12 – Process & Schedule**, without extra cost to the Town

### 9. Proposal Submittals Requirements

Each response to this RFP will be evaluated to select the most highly qualified providers. Proposals will not be opened in public and will not be made public until an award has been made. Proponent's meeting the minimum requirements criteria outlined in below will advance to the proposal evaluation process.

The Town may conduct such investigations as the Town considers necessary to assist in the evaluation of any proposal and to establish the responsibility, qualifications and financial ability of the Proponent. The Town shall be the sole judge of the Proponent's qualifications and whether the proposal is in the best interests of the Town.

The Town will select the responsive and responsible Proponent with the most advantageous proposal, taking into consideration the Proponent's experience, references, Technical Proposal, and Price Proposal.

### Qualifications: (Submitted Separately)

The Proponent shall submit information demonstrating the experience of key firm or team members in wind energy generation project development and other energy generation project development:

- Proponent Qualifications and Experience: Proponent shall clearly demonstrate full knowledge, understanding, and experience in the methods, techniques and guidelines required for the permitting and installation of a renewable energy facility. Proponent must demonstrate the experience and capability to perform the work on schedule and be responsive to Town and State, permitting authorities and the Town. Proponent to provide detailed listing of experience as owner/operator of similar facilities.
- Personnel Qualifications and Availability. Specialized experience is required of the proposed project personnel to undertake the work assignments. Proposals must clearly demonstrate the capability, academic background, training, certifications and experience of the proposed personnel. The availability of the proposed staff is also of crucial importance and must be demonstrated. Specific project responsibility of staff to be assigned to the Project must be included, as well as professional background and caliber of previous experience of key persons and of each consultant to be assigned to the project.
- Use of Sub-consultants. Proponent to identify the use of sub-consultants including the specific experience if the sub-consultant is to be used in the installation of the renewable energy at the site.
- A list of similar projects that the Proponent has worked on in the last five years. Information should include the project name, project address, project description, project date, contact name, contact title, and contact phone number.
- Performance Record of Proponent. A list of references of at least three (3) recent contracting officers of projects of similar nature, magnitude and complexity; references must include full contact information, as well as a brief explanation of the referenced work. Include the individuals on staff who had responsibility for each project and whether or not these people are still employed by the proponent.
- Financial information demonstrating the capability of the firm or team to complete the Project successfully. See Section 24 for Financial Capacity requirements. Significant deviation in the audited financial statements from information submitted with the qualifications will be cause for termination of final negotiations.
- Proponents shall submit proof of ability to attain a bond in the amount of \$250,000 from a reliable and reputable firm and said proof shall be signed by an officer at the bonding company authorized to provide such a bond.

# Minimum Requirements: (Submit in Envelope 1 marked "Minimum Requirements")

Proponent must meet Minimum Requirements in order for the Review Team to evaluate the Technical Submittal and Price Proposal.

- Timely submission of the proposal.
- Meeting all terms and conditions of the RFP.
- Submission of a letter of transmittal signed by the individual authorized to negotiate for and to submit a proposal, and any related votes of the corporation or Board of Directors as necessary proof of authorization.
- Submittal sealed envelopes for "Minimum Requirements", "Technical Submittal", and "Price Proposal".

# Technical Submittal: (Submit in Envelope 2 marked "Technical Submittal"

If a Proponent meets the Minimum Requirements outlined above, then the evaluation of the Technical Submittal and Price Proposal will be conducted by the Review Team selected by the Executive Administrator based on the following and the attached Design and Performance Specifications:

- Technical Approach and Schedule: Proposal shall include an explanation of how the proponent will approach the various tasks, including scheduling, methods of construction, power supply, interconnection, and permitting.
- Project Understanding. The Proponent must demonstrate a comprehension of the role and function of this contract in meeting the needs of the Town. In addition to the understanding of the scope and approach, the Proponent must demonstrate the following, which will be considered in the section:
  - Proponents shall identify all environmental permits required for this site.
- Explanation and proof of a viable Financing Plan for the project along with proof of the viability and commitment of the Financing Party plus experience of the Financing Party with renewable energy projects.
- Other Relevant Issues. The Town may evaluate the importance of other relevant issues presented by the Proponent.
- Proposal must include a description of the electrical interconnection strategy. This description shall include a layout of the electric path from the site to a delivery point; including single line electrical drawing(s) representing interconnection with a grid tied electrical distribution system. The Selected Proponent will be responsible for obtaining a utility interconnection agreement as required.

- Proposal shall include preliminary plans that include:
  - Vegetation Control Plan around the renewable energy facility after installation.
  - Operations and Maintenance Plan for the subject property for the term of the Power Purchase Agreement considering all state and federal requirements for the property.
  - Security Plan (to protect the system from damage from individuals).
  - On-going Maintenance Plan for the renewable energy facility for the term of the Power Purchase Agreement.
  - Plan for staging and construction area at the renewable energy facility.

If a Proponent has provided satisfactory response to the Technical Submittal requirements, then the evaluation of the Price Proposal will be conducted by the Review Team.

#### Price Proposal: (Submit in Envelope 3 marked "Price Proposal")

All Price Proposals shall consist of annual payments to be made to the Town in the following ways:

### **Net Excess Generation Purchase Proposal – "Virtual Net Metering Proposal"**

Proponent shall propose the virtual net metering proposal for the first 20 years of the renewable energy project's commercial operation. The Town prefers a fixed price per kWh over the term of the agreement with no inflation. All proponents shall identify any necessary revisions to the attached model Power Purchase Agreement as well as their acceptance of the remaining language.

**Best Price Criteria.** The "best" Proposal price will be determined by two factors:

- 1. The greatest total financial return to the Town over the length of the contract.
- 2. The highest protection to the Town against risk.
- 3. The willingness and use of the attached model Power Purchase Agreement.

#### 10. Power Sales Agreement

If after successful negotiations a proponent is selected, the proponent will be required to execute a Power Purchase Agreement (PPA).

### 11. Proposal Evaluation and Notification of Results

Proposal Evaluation. Following receipt of the proposals, a Review Team selected by the Executive Administrator will rank the proposals and will begin negotiations with the most advantageous proponent taking into account the evaluation criteria and the price proposal. That proponent will then have sixty (60) days from the date of the award to provide written confirmation of financing or the award will be withdrawn and negotiations will begin with the

second most advantageous proponent. If need be, the process will be repeated for the third ranked bid.

**12. Process and Schedule.** The Town anticipates that it will use the following schedule for processing this RFP:

#### Schedule:

August 23, 2011
September 7, 2011
September 9, 2011
September 16, 2011
September 23, 2011
September 30, 2011
October 7, 2011
December 2, 2011

#### \*\*See Section 3

### **Proposal Submission Date:**

2:00 p.m., October 7, 2011, at the Office of the Select Board Office, 400 Slocum Road, Dartmouth, MA 02747. Any proposal received after this date and time may be rejected without further consideration. The Town reserves the right to extend the due date should it be determined to be in its best interest.

### 13. Disqualification of Proponent

Although not intended to be an exhaustive list of causes for disqualification, any one or more of the following causes, among others, may be considered sufficient for the disqualification of a Proponent and the rejection of a bid:

- A) Evidence of collusion among Proponents;
- B) Questions of lack of competency as revealed by either experience or financial statements; or
- C) Default on a previous contract for failure to perform.

#### 14. Licenses

If required by law for the operation of the business or work related to this RFP, the Proponent and all sub-contractors must possess all valid certifications and/or licenses as required by federal, state, and local laws.

#### 15. Non-Discrimination

The Proponent shall not discriminate against any person because of race, gender, age, disability, ancestry, religion, national origin, sexual preference, veteran status, or political affiliation or belief.

# 16. Permits, Approvals and Site Specific Requirements

The Selected Proponent shall be responsible for obtaining all relevant approvals and permits associated with the Renewable Energy Project. These may include, but are not limited to: construction permits, sediment and erosion control permits, electrical permits and interconnection agreements with the local utility. All permits shall be submitted under the direction of a licensed professional engineer. The costs for these approvals, agreements and permits shall be borne by the Selected Proponent. The Town will provide guidance, and support to the extent practical.

#### 17. Codes and Standards

The Selected Proponent shall meet all applicable industry standards and requirements for all equipment utilized.

#### 18. Financial Assurance for System Decommissioning

The Selected Proponent will be required to post financial assurance to cover the costs of removal of the renewable energy project, removal of all electrical connections and equipment, and the legal proper disposal of all equipment and waste. The calculation shall also include all costs for returning the property to pre-project conditions. The calculations shall include all professional costs, labor costs, trucking costs, hauling and disposal costs, landscaping costs, and any other cost not mentioned but which is expected to be incurred.

#### 19. Indemnification

The Selected Proponent shall be required to indemnify the Town officers, employees and contractors against any claim for performance of the Selected Proponent's contractors' services contemplated by this RFP. The Selected Proponent shall assume all risk of and responsibility for, and agrees to indemnify, defend, and save harmless the Town, its officers and employees from and against any and all claims, demands, suits, actions, recoveries, judgments, costs and expenses in connection therewith, on account of the loss of life, property or injury or damage to the person, body or real property or tangible personal property of any person or persons whatsoever, which shall arise from or result directly or indirectly from the work and/or materials supplied under this RFP and the resulting Power Purchase Agreement.

### 20. Insurance Requirements – Construction Phase

Prior to commencement of this Agreement, the Contractor shall obtain at its own cost and expense, the required insurance from insurance companies licensed in their state, carrying a Best's Financial Rating of "A-" or better, and shall provide evidence of such insurance to the Town of Dartmouth (The Town). The policies or certificates thereof shall provide that thirty days prior to cancellation or material change in the policy, notices of same shall be given to The Town by registered mail, return receipt requested, for all of the following stated insurance policies.

If at any time any of the policies required herein shall be or become unsatisfactory to The Town as to form or substance, or if a company issuing any such policy shall become unsatisfactory to The Town, the Contractor shall upon notice to that effect from the Town promptly obtain a new policy, submit the same to The Town for approval and submit a certificate thereof. Upon failure of the Contractor to furnish, deliver and maintain such insurance, the Agreement, at the election of The Town, may be declared suspended, discontinued or terminated. Failure of the Contractor to provide and maintain any of the required insurance shall not relieve the Contractor from any liability under the Agreement, nor shall the insurance requirements be construed to conflict with or otherwise limit the contractual obligations on the Contractor concerning indemnification. The Town may waive the requirement of coverage type or amount if not reasonably available and if The Town deems it to be in the best interest to do so.

# 21. Minimum Scope and Limits of Insurance

The Selected Proponent shall provide coverage with limits of liability not less than those stated below:

- **A.** Contractor shall maintain workers compensation, general liability, automobile and umbrella insurance for the minimum amount required by the general contract that this subcontract applies to or as outlined below, whichever limits and coverages are higher. Insurance coverages and certificates shall be provided and include <u>The Town of Dartmouth</u> as an additional insured, on a primary and non-contributory basis, on all liability policies.
- **B.** Minimum required insurance limits (coverage on an occurrence basis): Commercial General Liability
  - \$2,000,000 Products/Completed Operations Aggregate
  - · \$2,000,000 General Aggregate
  - · \$1,000,000 Any One Occurrence
  - \$1,000,000 Personal and Advertising Injury

### Automobile Liability

• \$1,000,000 Combined Single Limit -include owned, hired and non-owned auto

Commercial Excess Liability ("Umbrella")

- \$5,000,000 Products/Completed Operations Aggregate
- · \$5,000,000 General Aggregate
- · \$5,000,000 Any One Occurrence

# Contractors Pollution Liability Insurance

- \$1,000,000 Per Occurance
- \$1,000,000 In the Aggregate

# Employers Liability (Coverage "B" on the Workers Compensation Policy)

- \$ 500,000 Each Accident
- \$ 500,000 Each Employee for Injury by Disease
- \$ 500,000 Aggregate for Injury by Disease

### Builders' Risk Insurance or Installation Floater

In an amount equal to the initial amount for the construction of the Renewable Energy Project. The Town and the Selected Proponent and subcontractors shall be "Insureds" on the policy. Coverage shall be written on a special form, replacement cost basis and shall include coverage for soft costs.

Policy shall be endorsed such that the insurance shall not be canceled or lapse because of any partial use or occupancy.

Policy must provide coverage from the time any covered property becomes the responsibility of the Selected Proponent, and continue without interruption during construction, renovation, or installation, including any time during which the covered property is being transported to the construction installation site, or awaiting installation, whether on or off site

- C. Any contractor who does not carry worker's compensation insurance coverage to protect himself personally from work-related injuries hereby fully releases, holds harmless, and indemnifies The Town of Dartmouth from any injuries that may occur to the contractor himself during the course of this project. In no way does this provision affect the absolute duty of every contractor to provide workers' compensation insurance coverage to each and every one of his employees and himself according to the provisions of this Agreement and all applicable state and federal laws.
- D. To the fullest extent permitted by law, the contractor hereby acknowledges and agrees that it shall indemnify, hold harmless and defend the Town of Dartmouth, the Owner, Architect and Engineer and any of the officers, directors, employees, agents, affiliates, subsidiaries and partners from and against all claims, damages, losses and expenses, including but not limited to, attorney's fees, arising out of or resulting from the performance of the contract's Work under this contract, provided that any such claim, damage, loss or expense (1) is attributable to bodily injury, sickness, disease, or death or injury to or destruction of tangible property (other than to the Work itself) including loss

of use resulting there from, and (2) is caused in whole or in part by any acts or omissions of the contractor, its employees, agents or sub-contractors or anyone directly or indirectly employed by any of them or anyone whose acts any of them may be liable.

E. All Insurance Certificates must contain a clause indicating that certificate holders be given a minimum of 30 days written notice prior to the cancellation of contractors insurance. Contractor must furnish the certificate referred to above as an express condition precedent to the Town's duty to make any progress payments to contractor pursuant to this Agreement.

The contractor hereby acknowledges its obligation under the forgoing paragraph to indemnify The Town against judgments suffered because of the contractor's work and to assume the cost of defending the general Contractor against claims as described in the forgoing paragraph.

### 22. Insurance Requirements – Operation Phase

The Selected Proponent and subcontractors shall procure and maintain until all of their obligations have been discharged, including until any warranty periods under the Property Lease Agreement are satisfied and any insurance claims for injury to persons or damage to property which may arise from or in connection with the performance of the work by the Selected Proponent, its agents, representatives, employees, or subcontractors are dealt with.

The insurance requirements herein are minimum requirements for the Power Purchase Agreement and in no way limit the indemnity covenants contained in this RFP.

The Town in no way warrants that the minimum limits contained herein is sufficient to protect the Selected Proponent from liabilities that might arise out of the performance of the work under the Power Purchase Agreement by the Selected Proponent, its agents, representatives, employees, or subcontractors. The Selected Proponent is free to purchase such additional insurance as may be determined necessary.

#### 23. Additional Insurance for Operation Phase

All of the insurance listed above in Section 21 shall remain in effect and full force for the term of the Power Purchase Agreement. In addition, the Selected Proponent shall procure and maintain the following insurance:

# A. Property Insurance

Property insurance shall be written on an all risk, replacement cost coverage.

Policy shall be in force at the time of substantial completion of the project's construction and continue until the termination of the Property Lease Agreement.

# 24. Financial Capacity

- Annual reports or other current audited financial data of the Proponent shall be submitted for the prior 3 years.
- Proponents must identify specifically those portions of their financial history, if any, which they believe contain confidential information. These portions of the Proponent's submittal treated as confidential under Section 1.7 will not be released as public documents.
- The Proponent must demonstrate its ability to obtain project financing.

# 25. Business Registration

The Proponent will provide proof of valid business registration in the state in which it's main office or headquarters is located.

The Proponent will provide proof of business registration with the United States Internal Revenue Service (Federal Employer Identification Number).

#### 26. Performance Bond and Insurance

The Proponent will provide a certification from a Corporate Officer that the Proponent will meet the bond and insurance requirements outlined in this RFP and that any subcontractor utilized will meet the same insurance requirements.

#### 27. Submittal Format

In addition to the Proposal Requirements stated within, the Proposal shall also consist of the following:

- Minimum Requirements SEALED ENVELOPE
- Technical Submittal SEALED ENVELOPE
- Price Proposal SEALED ENVELOPE

# FORM 1

# **CERTIFICATE OF NON-COLLUSION**

The undersigned certificate under penalties of perjursubmitted in good faith and without collusion or frau Certification, the word "person" shall mean any corporation, union, committee, club, or other organization.	id with any other person. As used in the natural person, business, partnership,
Signature	Date
+++++++++++++++++++++++++++++++++++++++	+++++++++++++++++++++++++++++++++++++++
CERTIFICATION TO COMPLIAN	NCE WITH TAX LAWS
I, the duly authorized representative of and penalties of perjury that said the Commonwealth of Massachusetts relating to taxes	certify under the pains has complied with all laws of s.
Signature	Date
+++++++++++++++++++++++++++++++++++++++	-++++++++++++++++++++++++++++++++++++++
DISCLOSURE OF BENEFIC	IAL INTERESTS
The undersigned certifies under penalties of perjury submitted with the below as required by Chapter Massachusetts. The following names and addresses have a direct or indirect beneficial interest in the su offers to lease a portion of the parcel to the undersign	7, Section 40J of the General Laws of represent all persons who have or will ubject parcel if the Town of Dartmouth
<u>Name</u>	Address
Signature	Date

#### **TOWN OF DARTMOUTH**

#### WIND ENERGY PROJECT

#### **DESIGN and PERFORMANCE SPECIFICATION**

# A. Project Description

The Town is proposing two wind turbines with a minimum power rating of 1.6 MW each on Town owned land. The Project sites are:

- 1. The approximately 120 acre Dartmouth Water Division's Chase Road Well Site ("Chase Road Site"), and
- 2. The approximately 120 acre Waste Water Treatment Facility on Russells Mills Road ("Russells Mills Road Site");

The locations of these sites are shown in Appendix B.

The Town will only consider proposals for wind projects that meet its minimum requirements for wind turbine noise and blade shadow flicker.

# **B.** Site Description

The sites have been fully assessed by a number of feasibility studies. The sites have a wind resource greater than 6 mps at 80 meters and an adequate utility distribution network within 1000 feet of each turbine. The possible building envelope is defined by wetlands and appropriate set backs from the adjacent low density residential properties.

The FAA has issued a No Effect Height (NEH) determination of 417 feet.

The turbines selected should be readily available from reputable turbine suppliers, with robust after sales service and warranty support in the United States.

Parameter	Minimum or Equivalent Value
Turbine Capacity	1,600 kWh each x 2 = 3,200 kW. Larger turbines are permitted as long as they meet the maximum noise and blade shadow flicker requirements listed below
Turbine Manufacturer and Model	GE 1.6 xle turbine or equivalent
Rotor Diameter	80 meters (or greater)
Wind Speed Estimate at 70m	5.88 m/s @P50
Hub Height	75 meters (limited by FAA NEH of 417 feet)
Wind Speed Translated to 80 m Hub Height	6.14 m/s @P50 5.86 m/s @P75 5.56 m/s @P90
Estimated Annual kWh Output	7784 MWh (P50 – 2 turbines)
	6866 MWh (P75 – 2 turbines)
	6066 MWh (P90- 2 turbines)
Noise	Less than 106 dB(A) Maximum, with the availability of Noise Reduced Operation Capability to limit measured combined turbine noise to no more than 10 dB(A) above ambient noise at the project property lines during periods of low ambient noise.
Blade Shadow Flicker	Preferred: Less than 20 hours at nearest residential neighbor. Required: Less than 30 hours at all off-site neighbors within Blade Shadow Flicker Effect Zone

There are wetlands in the area, and adjacent wetlands are currently being delineated at the Russells Mills Road Site. A Notice of Intent will be required to be filed with the Department of Environmental Protection and local Conservation Commission. A determination of wetland setbacks for all access roads and the turbine siting will be finalized upon issuance of the Order of Conditions for the project. The final design and all work must comply with the Town of Dartmouth Conservation Commissions' Order of Conditions. The area is wooded, so tree clearing will be required at and around the turbine sites. It is anticipated that extensive erosion and sediment control measures will be required for the project. All environmental requirements shall be the responsibility of the Wind Energy Project Developer.

The Town has several facilities in the vicinity: the Wastewater Treatment Plant, the Drinking Water Filtration Plant and several wells and associated pumps. The surrounding neighborhood mixed low density suburban, farm, and large tracts of undeveloped land.

#### i. Land Use Restrictions

There are no use restrictions on the sites. At the June 1, 2010 Town Meeting, the Town passed a Land-Based Municipal Wind Turbine Bylaw which allows a Municipal Wind Energy Conversion Facility (WECF) by right in all districts of the Town, provided that certain standards are met. The proposed site meets the standards set forth in the Bylaw. At the June 2011 Town Meeting, the Town authorized the leasing of land for this Project.

Proximity to nearest publicly accessible land and the requirements according to the Town turbine siting Bylaw is as follows:

	Setback required	Distance (ft.)*
Closest occupied structure	No occupied structure within clear area defined as the area	Turbine 1: 1,220 ft.
	i	Turbine 2: 595 ft
	having a radius equal to the	
	Total Height	
Closest publicly accessible space		Turbine 1: 1,115 ft
(ex. Schools, roads, bike paths,		
parks)	n/a	Turbine 2: 595 ft
Closest offsite neighboring residential structure		Turbine 1: 1,220 ft.
	n/a	Turbine 2: 1,360 ft
Closest property line	2 times the hub height	Turbine 1: 1,115 ft
		Turbine 2: 1,050 ft
Closest wetlands (if within 1000 feet)	n/a	Turbine 1: TBD ft
		Turbine 2: TBD ft

#### ii. Site Location

See Appendix B for the location of the two sites for the WTGs. The latitude and longitude locations for the turbines are:

Site	Location
Site 1	Lat -41° 35' 25.59" Long -70° 59' 50.30"
Site 2	Lat -41° 35' 27.05" Long -70° 59' 38.35"

The proposed Chase Road site has adequate area to allow for crane pads and crane lay down areas, staging of wind turbine components, and for maneuvering heavy equipment. It is anticipated that the Russells Mills Road site will also have adequate construction area; however, this is subject to final approval of the wetlands delineation for the Russells Mills Road site by the Conservation Committee. Minor clearing of trees and overgrowth and some grading will be required before delivery of wind turbine components and commencing construction. Site preparation and restoration work will be the responsibility of the Wind Energy Project Developer.

### C. Environmental Permitting Status

The Town obtained an "Abbreviated Notice of Resource Area Delineation" that locks in the wetland/resource delineation for the Chase Road Site. That permit was not appealed by the opponents, so the resource delineation is finalized for three years. The Russells Mills Road site wetland resource delineation has been completed. The Abbreviated Notice of Resource Area Delineation is currently being filed by the Town. A determination of the final resource delineation will be made by the local Conservation Commission. It is anticipated that a Notice of Intent will be required to be filed with the Massachusetts Department of Environmental Protection and the local Conservation Commission for each of the turbine sites. See Appendix C for a detailed listing of Permit Status.

#### D. Electrical Interconnection Status

An initial electrical interconnection application was filed with the NSTAR for two 1.65 MW turbines in July 2010. The NSTAR Determination from this application indicated that there were no major impediments to this application.

Based on this determination, The Town prepared a new pro-forma interconnection application proposing GE 1.6 XLE turbines which would meet the utilities concerns with the earlier application. These (or comparable) turbines offer modern power electronics (with dynamic power factor correction and LVRT capability), which were not features offered by the turbines in the earlier proposal.

For this project it is anticipated that each turbine will have either its own pad mounted transformer at the base of the turbine (or an integral transformer in the nacelle) and its own primary (13.2 kV) lateral about 1000 feet out to the utility 13.2 kV distribution system on the main roads. Each turbine will be metered on the point of utility interconnection and have its own grid monitoring and fault detecting switchgear. According to utility records, the local distribution circuit is capable of conducting over 10 MW and the typical load at the substation varies from 4 MW to 8 MW.

The Wind Project Developer will supply the electrical connection to the utility, including underground 13.8kV cable, a switch, and transformer of requested size and voltage, site improvements allowing for truck and crane access to the selected sites, utility electrical connection, NStar interconnection agreement, electrical engineering and design, an updated FAA application and approval, and all construction permitting.

#### E. Climate Information

Refer to Wind Study in Appendix A.

# F. Summary of Work

The Wind Project Developer shall provide all engineering, site engineering and permitting necessary for the project. The Wind Project Developer shall provide construction for turbine site access and construction areas during installation.

The Wind Project Developer shall supply and install two complete WTGs, including nacelles, rotors, towers, foundations, electrical transformer, and primary voltage switch at the turbine site, and a remote monitoring and control system. The Wind Energy Project Developer shall be responsible for providing a point of interconnection for each wind turbine per the requirements of the NStar's electrical distribution system as well as national and local electric codes.

The Project shall commence power delivery and normal operation, fully complete and acceptable to the Town.

The response to the RFP must specify all the equipment and materials for the WTG system as specified below. The work shall include delivery of all equipment and materials to the job site, off-loading, receiving, and proper storage. The minimal equipment and materials required by this RFP include, but are not limited to, the following major items:

- 1. Towers, 75 meters high or taller (limited by the FAA NEH determination of 417 feet)
- 2. Nacelles
- 3. Rotor
- 4. Remote monitoring and control system and all related instrumentation
- 5. Lightning protection, including wind turbine factory approved grounding system
- 6. FAA lighting
- 7. Foundations, foundation anchor bolts, bolt sleeves, and concrete equipment bases or tower foundation embedment ring, as applicable
- 8. Turbine switchgear
- 9. Warrantees (include scopes, required durations, and acceptable limitations) and/or maintenance agreement terms. Warrantees shall cover scheduled and unscheduled maintenance during the warranty period and be offered for a minimum of 5 years.
- 10. All nuts, bolts, gaskets, special fasteners, backing rings, etc., between components and equipment furnished under these specifications
- 11. Coupling guards for all exposed shafts and couplings
- 12. First fill of lubricants, grease, coolant and hydraulic fluid for operation
- 13. Solvents and cleaning materials
- 14. Finish painting of all equipment
- 15. Manufacturer's recommended spare parts
- 16. Operating personnel for witness of startup and tests
- 17. Complete operating and maintenance manuals for the WTG(s) and related equipment

- 18. Complete set of as-built drawings for the wind energy conversion system and electrical power collection system including the utility interconnection point.
- 19. Each turbine shall have its own 120/240 V, 100 amp electrical service from the street or Town facilities. The service shall be independent of the main interconnection. The service shall connect to convenience receptacles and lights.

The equipment will be tested by the Wind Project Developer under observation by the Town or designated engineer after erection to demonstrate full operational status for commercial generation and fulfill the required guarantees.

The project shall comply with the Massachusetts Clean Energy Center's Minimum Technical Requirements for Community Scale Wind Projects. See Appendix C.

#### G. Codes and Standards

All materials, equipment, and fabrication procedures shall be in accordance with the latest applicable laws of the United States of America, the Commonwealth of Massachusetts, and all local ordinances. In the case of conflict between standards, the more stringent standards shall apply.

All required stamps shall be affixed to denote conformance to the appropriate codes. Code requirements shall be based on codes and standards in effect at the contract date for the WTG units and support structures.

Data reports required by the applicable codes shall be submitted to the Town or designated engineer.

International Electrotechnical Commission (IEC) Standard 61400-1 shall be used as the minimum acceptable design criteria. Any turbine design offered shall be certified as meeting 61400-1 requirements by Germanischer-Lloyd, Det Norske Veritas, or equivalent certifying agency.

#### H. Permits

Wind Project Developer shall obtain all necessary permits for transport and construction of the WTGs. The Town will cooperate and assist the Developer in securing permits when necessary.

### I. Transportation

Wind Project Developer shall be responsible for coordinating and performing all transport of equipment and materials to the site, including the cost of all permits and bridge survey engineering whether directly or through a transportation subcontractor.

# J. Design Criteria

All equipment shall be designed to operate reliably and continuously for a minimum useful life of 20 years of service.

Each WTG unit, including the rotor, generator, power conversion system, yaw system, pitch system, and related ancillary equipment shall be capable of operating at rated capacity, safely, reliably, continuously, and without undue maintenance under the environmental conditions (temperature, air density, wind speed, salinity, etc.) of this project.

### **K.** Design Submittals

The Wind Project Developer shall submit individual sets of calculations as reasonably requested by the Town. All sets shall be of similar format, self-explanatory and clear to review. Sets of calculations shall be submitted both electronically and in hardcopy, bound, titled, given unique numbers and indexed.

When required, the Wind Project Developer shall provide an explanation together with evidence to validate computer programs used for design calculations. Calculations and drawings shall always be submitted with document number, revision suffix and date of issue. All drawings shall be to scale and fully detailed, dimensioned and legible.

The Wind Project Developer will be responsible for the submission of calculations and drawings to the local authority for planning and building regulation approval. Immediately prior to such submission, the Wind Project Developer shall provide the Town with a complete set of all documents intended for inclusion in the submission.

Construction will not be permitted on site until the relevant designs and drawings have been reviewed and approved by the Town and the relevant local authority approvals have been obtained.

The Wind Project Developer shall support, cooperate with, and participate in the pre-design meetings or teleconference for every aspect of the Project's design. The Wind Project Developer shall use reasonable effort to accommodate the Town's preferences for the Project's design. The Wind Project Developer shall also submit the design drawings and calculations for each aspect of the Project's design to the Town for its review and comment at a point roughly equivalent to being 60 and 100 percent complete. Upon initial completion of each of the Project's design, all Project designs and calculations shall be submitted to the Town for its review and approval prior to construction. In all cases, the Town may engage an independent engineer to further review and approve design documents and calculations.

Review and approval of design documents by the Town or the Town's independent engineer shall not relieve Wind Project Developer of any responsibilities for completeness and sufficiency of the design nor in any way transfer the Wind Project Developer's responsibility for sufficiency of the work to the Town or the Town's independent engineer.

#### L. Performance Criteria

Complete performance data on the WTG units shall be submitted as requested herein:

- 1. Certification by a nationally accredited certification authority that the Turbines meet all sections of IEC 61400.
- 2. Power output vs. wind speed
- 3. Thrust coefficient vs. wind speed
- 4. Detailed information on the capability of the turbine generator to respond to a system faults, including which faults are recovered from automatically when the fault causing condition has been cleared and which faults require a manual operator restart, where a large portion of the system load is applied to the unit and load shedding is required
- 5. Reactive power requirement vs. real power capability curve

#### M. Performance Guarantees

The Wind Project Developer will provide copies of the available Power Curve, Technical Availability, and Noise Emission Performance guarantees as provided by the wind turbine manufacturer, or insurance company.

#### N. Manufacturer's Guarantees and Warranties

The Wind Project Developer will secure all manufacturer and vendor warranties, including but not limited to WTG warranties pertaining to defects in manufacturing materials, power curve, technical availability, and noise.

#### O. Testing

A complete Commissioning and Testing Plan shall be submitted to the Town or the designated engineer for approval. The Wind Project Developer shall provide notice, in writing, to the Town or its representative and to the local utility of its intent to start the system one week prior to the proposed startup date. After receiving written permission to start the system from the Town or its representative and the local utility the Wind Project Developer shall commission the system in keeping with all requirements of the Commissioning and Testing Plan.

Testing includes operational testing. Operational testing shall be completed within the first 30 calendar days that the WTG(s) are available for operation and conclude with a 168 hour continuous unmanned operation test.

The Wind Project Developer shall correct any deficiencies uncovered by testing prior to completion of commissioning of the system.

# 1. Wind Project Developer Retesting and Turbine Modifications

In the event the WTG(s) do not meet the Performance Guarantees specified in the contract, the Wind Project Developer may perform an additional power output performance test to verify the results of the previous test. There shall be no tolerances or allowances for testing error applied to the test results. The Wind Project Developer shall bear the "test related expense" costs for the test.

The "entire expense" means all charges incurred by the Wind Project Developer during the retesting other than Town-furnished energy and the Town's normal operating personnel. Furnishing and installation of additional instrumentation, instrument costs, data logging, computations, reports, and similar requirements necessary for the retest will be included as part of the "entire expense" cost.

The Town shall have the right to review the Wind Project Developer's test data, test calculations, all test data corrections, and test results. Disagreements or differences between the Town's and Wind Project Developer's calculations and analysis shall be resolved in a manner acceptable to the Town.

### P. System Interconnection

#### 1. General

The Wind Project Developer supplied equipment must interface with the NStar's 13.8kV distribution system. Wiring for systems operating at less than 50 volts shall be in separate metal enclosures from power system wiring, or in metal conduit if nearby power circuits at 120 volts and above are present in the same enclosure.

#### 2. Grounding

The grounding system must be designed to meet the following requirements:

- Proper grounding of equipment, structures, and installation of an adequate earth ground grid for safety to personnel and safe operation of equipment.
- Proper equipment grounding for lightning and surge protection.

The Project Developer shall provide installed, a comprehensive grounding system in accordance with the turbine manufacturers specifications. Grounding design shall be prepared by an electrical engineer registered in the state of Massachusetts. Grounding shall comply with applicable portions of the National Electrical Code (NEC). In addition local soil conditions and resistivity must be considered in the installation of the grounding system.

#### Q. Interconnection

The WTGs must interconnect to the NStar distribution system at 13.8 kV connection points. The Wind Project Developer shall supply all necessary equipment and labor to complete the interconnection.

Interconnection plans and application shall be submitted to the Town of Dartmouth for review prior to submission to NStar.

#### R. Protection

A the power quality monitoring and protection system shall be installed at the interconnection point to protect the Town's water and waste water treatment plant power systems and equipment in the case of system malfunction. This system must meet the requirements of both the Town and the local utility.

All system wiring shall be of an MEC approved wiring method. All conductors shall have a temperature rating of 90° C or higher.

All outdoor electrical enclosures shall be 4XSS(316) and have watertight connections.

Exposed cables shall be listed as sunlight resistant.

# S. Nameplate

The nameplate of the generator shall contain the applicable information according to ANSI C50.12.

# T. Instrumentation and Control System

#### 1. General

Wind turbines must be supplied with a Supervisory Control and Data Acquisition (SCADA) system capable of monitoring and recording the performance of the turbines and status of critical sensors. Data must be recorded and be available for at least the previous 1 year. Data must be exportable to a format compatible with Microsoft Excel. The Wind Project Developer shall provide a control and monitoring connection including hardware (a dedicated desktop computer with the necessary SCADA software for remote access by the Town.

### 2. Description

The control system shall automatically control all operations of the wind turbine, optimize output of the generator, process all alarms, log events and performance data, and transmit real-time performance data and alarms to a remote location.

The instrumentation and control system shall operate automatically under all operating conditions and conditions of power availability. This operation shall include automatic startup and shutdown for normal operations. Upon loss of utility power interconnection or failure of utility power, restart of the instrumentation and control system to a full functioning condition shall require no local manual operations.

# 3. Connection with Plant Control System

The Wind Project Developer shall provide all necessary hardware, and installation and integration services required to allow the Town to connect an Ethernet line to the turbine, and make an OSI PI capable interface connection. The indications and alarms shall include real-time performance parameters, operation counters, and alarms. These indications and alarms shall be sent to the remote location and also logged and displayed locally at the operations or control panel.

#### U. Main Power Switching

#### 1. General

The Wind Project Developer shall provide main power hard and soft switching.

# 2. Description

The main power switching shall be performed in such a manner as to limit the inrush current. The Wind Project Developer shall provide a description of the main power switching scheme.

If thyristors are used, they shall meet the applicable requirements of IEEE 444. The thyristors shall be fully rated for the application and shall not be damaged due to failure of the power Wind Project Developer to perform its function. Failure of the thyristors shall cause an alarm to be indicated.

#### V. Main Power Connection Switchgear

#### 1. General

The Wind Project Developer shall furnish and install switchgear connected to the utility electrical system.

### 2. Description

The switchgear shall consist primarily of a main circuit breaker unit, along with associated equipment. All equipment and its installation shall meet applicable NEMA and ANSI or IEC standards.

The equipment shall be provided in a dedicated steel enclosure and be readily accessible for inspection and maintenance. The circuit breaker compartment shall have a hinged door and dead front construction. No exposed buswork or cable connection shall be present with the breaker door open. Plexiglass barriers may be used to prevent contact with live parts.

#### 3. Main Circuit Breaker

The main circuit breaker shall be an electrically operated low voltage type of standard manufacturer. The trip unit shall be fully adjustable solid state type, designed for the protection

of the all equipment. The circuit breaker ampere rating shall be at least 125 percent of the generator full load rating with no power factor correction. The minimum interrupting rating shall be the larger of the generator fault current or the utility supplied fault current, based on the wind turbine generator rating. Circuit breaker insulation and voltage ratings shall be coordinated with the Wind Project Developer's complete generator and cabling system.

# 4. Auxiliary and Control Power Supply

The Wind Project Developer shall provide the necessary auxiliary and control power supplies for all modes of wind turbine operation. All auxiliary and control supplies shall be from circuits with their own circuit protective device.

#### 5. Rotors

Rotor, hub, tower, and all components shall be constructed of new and unused materials. The blades and hub shall be designed to operate at the site conditions specified in Appendix A of this RFP for the design life of the wind turbines. Blades shall be manufactured with UV protection as an integral part of their construction. To minimize blade washing frequency, blades shall be manufactured such that they are resistant to roughness degradation.

#### W. Towers

### 1. Tower Type and Material and Tower Access

The wind turbine tower shall be a steel tower of the monopole tubular type. Tower height shall place the center of the rotor at a minimum of 75 meters above the foundation. Tower shall be furnished with paint which meets C3 standards for corrosion resistance on the outside and C2 standards for corrosion resistance on the inside.

The tower shall be accessible through a secure lockable access door at the base of the tower. Permanent metal stairs shall be provided if the access door is above grade level.

#### 2. Tower Ladder Plus Lift

Provide both a ladder and lift. The tower ladder shall be of the manufacturer's standard type. The tower ladder shall meet all OSHA standard requirements for safety and construction. The tower ladder shall allow access to all equipment.

#### X. Lighting

The tower and nacelle shall be of the manufacturer's standard type. Lighting shall provide adequate visibility for day or night work inside the tower and shall be operational from the bottom or top of the tower. Tower lighting shall meet OSHA requirements for working environments. Emergency lighting shall provide up to four hours operation on battery. Emergency lights shall be provided for the nacelle, ladder, and ground level interior locations.

#### Y. Nacelle

The nacelle shall house and protect the generator, drive train, lubrication system, and associated equipment. The nacelle shall provide adequate working space for service and maintenance work. Access to the rotor hub and system instrumentation shall be safely achievable from inside of the nacelle.

#### 1. Ventilation

The tower and nacelle shall be provided with proper ventilation.

### Z. Aviation Lighting

Each wind turbine shall be equipped with aviation lighting as required by the Federal Aviation Administration and all other applicable standards. Lighting shall be a red flashing light, type L-864 or equivalent, on each turbine. Flashing of lights shall be synchronized.

#### AA. Foundations

The Wind Project Developer shall engineer, design, and install foundations for the WTG(s). The Wind Project Developer shall perform all necessary geotechnical work for proper design of the foundations. Foundations will be designed to meet all WTG manufacturers' required loads. Preliminary geotechnical information will be made available on the project bidding web site. The Town will provide soil borings for the WTG sites. Appendix B includes a boring adjacent to site of Turbine 1. The Town of Dartmouth is preparing a boring at Turbine 2. The borings are provided as reference and actual conditions may vary from that shown on the boring logs. The Wind Project Developer is responsible to specify in the proposal any further geotechnical investigations necessary for design of turbine foundations. The proposal should include a ten percent buffer for foundation design to account for any changes in geotechnical information.

### **BB.** Training

The Wind Project Developer shall provide operations orientation for Town facilities and emergency response personnel upon commissioning of the project. The orientation shall include the provision of an emergency response plan for review and approval by the Town of Dartmouth. The plan shall include procedures and responsibilities for responding to wind turbine emergencies. Emergencies shall include, system alarm, system failure, weather related emergencies, natural disasters, critical equipment failures, actions by trespasser on the leased property, and turbine electrical and structural emergencies. It shall also provide timelines for response, identify responders, and provide coordination required by local officials. The plan shall clearly define emergency actions, responsibilities, and costs which are the responsibility of the developer and those identified as the responsibility of the Town of Dartmouth.

In the event of a transfer of the project ownership to the Town, the Developer shall provide 40 hours of on-site operations and maintenance training of Town personnel. Training will be sufficient to allow for the Town's personnel to handle day-to-day operations of the WTGs. Training shall cover:

- 1. Wind turbine basics
- 2. Turbine operation
- 3. Start-up
- 4. Shut-down
- 5. Mechanical maintenance
- 6. Electrical maintenance
- 7. Troubleshooting and fault clearing

# **CC.** Uninterruptible Power Supply (UPS)

The wind turbines shall be equipped with an uninterruptible power supply (UPS) for storage of data in the controller and for safe egress in the event power from the grid is lost. The UPS shall provide a minimum of 4 hours of uninterrupted power for these functions. In the event of long-term power loss, the wind turbine controller must not lose previously collected data.

#### **DD.** Lightning Protection

The wind turbines shall be furnished with lightning protection covering all aspects of the turbine, including but not limited to blades, generator, gearbox, and control system. The system shall comply with the current edition of the following codes and standards:

- 1. IEC 61024-1 or IEC 61400-24
- 2. National Fire Protection Association, NFPA 780, "Lightning Protection Code."
- 3. Underwriters' Laboratories, Inc., UL 96A, "Installation Requirements for Lightning Protection Systems."
- 4. Underwriters' Laboratories, Inc., UL 95, "Lightning Protection Components."
- 5. NEC.
- 6. Any applicable local codes.

The Wind Project Developer's design and equipment furnished shall meet all requirements to receive the Master Label of the Underwriters' Laboratories, Inc., for the site. The Wind Project Developer's lighting protection system design and equipment furnished will not be considered acceptable prior to attachment of the Master Label plate at the site.

#### **EE.** Corrosion Protection

All ferrous materials shall be supplied with coating systems adequate to protect the equipment from corrosion for the design life of the turbines at the proposed locations.

# FF. Scheduled Maintenance

Scheduled maintenance shall be performed at no more than manufacturer's recommended intervals in accordance with manufacturer specifications. If manufacturer's recommended intervals are longer than 6 months apart, maintenance shall be performed at a minimum of 6-month intervals.

# APPENDIX A

WIND DATA



# Renewable Energy Research Laboratory

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# **Dartmouth: SODAR-Based Wind Resource Assessment**

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January 16, 2009

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# **Executive Summary**

This report summarizes the wind data collected at the Dartmouth landfill using one of the Renewable Energy Research Laboratory's (RERL) two SODAR (Sonic Detection and Ranging) units for the purpose of wind resource assessment.

Wind speed and direction were measured at a site in Dartmouth, MA (Lats and Longs) between November 14<sup>th</sup> 2007 to January 24<sup>th</sup> 2008 and between March 14<sup>th</sup> to May 30<sup>th</sup> 2008. The data obtained from this site were analyzed and compared to 49 m anemometer data collected at the Old Rochester Regional (ORR) High School in Mattapoisett, MA. Based on the comparison between the SODAR site and the tower data, the validity of the SODAR data was confirmed. Discuss any major issues with the data or changes made to measurements, etc.

Wind data collected at the BUZM3 buoy in Buzzards Bay since 1997 was used as a reference site and a Measure-Correlate-Predict (MCP) algorithm was used to predict long-term wind speeds at the Dartmouth site. The buoy is located at 41°23'48" N 71°2'0" W and the anemometer is mounted at 24.8 m.

After conducting the MCP analysis, the predicted wind speeds were adjusted to account for the bias in the SODAR data caused by vector averaging effects as well as by volume averaging effects. Long-term average wind speeds were predicted at a range of heights (40 m to 160 m). The following table shows the predicted wind speeds and the expected range of uncertainty from 80 m to 120 m at Dartmouth.

	Predicted wind			P90 wind
Height	speed	Minimum	Maximum	speed
[m]	[m/s]	[m/s]	[m/s]	[m/s]
80	6.03	5.30	6.76	5.40
90	6.24	5.50	6.99	5.60
100	6.54	5.69	7.38	5.80
110	6.66	5.76	7.56	5.88
120	6.91	5.98	7.83	6.10

The prevailing wind direction at the site is from the South-West direction. The estimated shear exponent at this site was found to be 0.339 from 40 m to 120 m.

Capacity factors were estimated at hub heights of 60 m and 80 m, using the Vestas V80 power curve. The following table shows the predicted capacity factors:

	Rated	Hub	Capacity Factor with		actor with	
Turbine	Power	Height	Capacity Factor		loss	es
			Predicted	P90 wind	Predicted	P90 wind
	[kW]	[m]	wind speed	speed	wind speed	speed
Fuhrlaender	250	50	0.14	0.09	0.11	0.07
Vestas V52	850	49	0.14	0.09	0.10	0.07
Siemens/Bonus	1000	60	0.16	0.12	0.12	0.09
GE 1.5 xle	1500	80	0.29	0.23	0.23	0.17

An uncertainty analysis was conducted and each source of significant error was quantified and accounted for. These sources of errors included the error of the SODAR, the uncertainty of the MCP analysis and inter-annual variability. The uncertainty ranges stated above include all of the significant sources of uncertainty.

# Introduction

As electricity prices continue to increase and with growing concerns of global warming, renewable energy sources are steadily burgeoning in popularity. Currently, the most economical renewable source for electricity generation is wind energy. Since Eastern Massachusetts is home to an abundant source of wind, many towns and communities are actively pursuing the installation of wind turbines. When evaluating the viability of a wind turbine installation, one of the most important parameters is the wind resource at the site. This report summarizes the wind resource assessment carried out by the Renewable Energy Research Laboratory (RERL) at the University of Massachusetts, Amherst for the town of Dartmouth, MA.

The traditional method of collecting wind data is through the use of cup anemometers mounted on meteorological (met) towers. The maximum height for a typical met tower is 50 m. Therefore the estimated wind speeds must be extrapolated up to higher heights when estimating the wind resource at heights of interest for wind energy. With the increasing size of modern wind turbines and higher hub heights, this traditional method leads to an increase in uncertainty and is therefore becoming less desirable.

SODAR (Sonic Detection and Ranging) offers an alternative approach to estimating wind speed. As will be explained in a subsequent section, SODAR measures wind speed by emitting high frequency acoustic waves and recording the Doppler shift of the reflected signal. The wind speed is calculated at a range of heights (from 30 m to 160 m). SODAR can therefore provide more information about the wind resource at a site than a typical met tower assembly.

RERL's SODAR trailer unit collected wind data at Dartmouth, MA between November 14<sup>th</sup> 2007 to January 24<sup>th</sup> 2008 and March 14<sup>th</sup> to May 30<sup>th</sup>, 2008. This report presents the measured data that was obtained during this time and the results of the data analysis. Anemometer wind data measured at the Old Rochester Regional High School in Mattapoisett MA were used to validate the SODAR data and the data collected at the BUZM3 buoy was used with the SODAR data to estimate the long-term wind speed at a range of heights (40 m to 160 m).

# **Outline of Report**

Prior to discussing the data collected at Dartmouth, an overview of SODAR operation is given. The basic functionality of SODAR is discussed and the filters used to determine valid data are presented. Also, some of the limitations of SODAR are identified. These include the effects of echoes caused by ground clutter (i.e. trees, buildings, etc.) and the inability to measure wind speed during precipitation.

Following this, the data analysis methodology is explained. Since ground clutter may contaminate SODAR readings, near-by anemometer data must be used to validate or to discredit the SODAR data at each height. Also, since gaps will exist in the SODAR data,

due to data filtering and precipitation, anemometer data must be used in conjunction with Measure-Correlate-Predict (MCP) to determine average wind speeds at the SODAR site over a range of heights.

After the methodology has been presented, the location and duration of data collection at Dartmouth is discussed. The data is presented and is compared to the near-by anemometer data at the Old Rochester Regional High School. Based on the correlation and average ratio between the SODAR and tower data, valid height ranges are determined

The results from the MCP analysis using the valid SODAR data and the long-term data are then presented. The long-term predictions are adjusted to account for vector and volume averaging effects. An uncertainty analysis is also conducted. All significant sources of errors are discussed and included in the overall uncertainty of the predicted wind speeds. Next, capacity factors based the Vestas V80 power curve are estimated for hub heights of 60 m and 80 m. Finally, a summary and discussion of the results are given as well as some concluding remarks.

# **Overview of SODAR Operation and Data Filtering**

# **SODAR Operation**

The SODAR trailer unit owned by RERL is an ART Model VT-1. This is described as a monostatic (it emits and receives the signal from the same location) phased-array SODAR. High frequency acoustic waves (~4500 Hz) are emitted from the SODAR in three consecutive directions: one in the vertical direction (W) and two in orthogonal directions approximately 17 degrees from vertical. The horizontal wind speed components, U and V, are calculated from the two orthogonal tilted beams. After each signal is emitted, a portion of the acoustic energy is backscattered due to fluctuations of the refractive index of air and is returned to the SODAR at some shifted frequency. The SODAR measures the reflected signal and calculates the shifted frequency at each height (from 30 m to 160 m at 10 m intervals). This shift in frequency is called the Doppler shift.

The Doppler shift refers to the change in frequency from a moving source as measured by a fixed observer. The amount of this apparent frequency shift is directly related to the velocity of the moving source (i.e. wind speed). Therefore, after every chirp, the SODAR calculates the wind speed in the direction of the beam at each specified height (range gate). The default range gate heights are from 30 m to 160 m at 10 m increments. The wind speeds are then averaged in each direction (U, V and W) over a ten-minute interval and the average vector wind speed and wind direction are determined at each range gate.

Note: Vector Wind Speed =  $\sqrt{(U \text{ Speed})^2 + (V \text{ Speed})^2}$ where U Speed and V Speed are corrected for Vertical Speed (W)

It should be noted that the SODAR measurement differs slightly from an anemometer measurement. The SODAR measures the instantaneous wind speed components and then averages them to determine the vector wind speed. Anemometers measure the instantaneous wind speed (i.e. U and V components are indistinguishable) and the average scalar wind speed is calculated. The scalar wind speed is typically  $1-2\,\%$  higher than the vector wind speed. The difference between the scalar average and the vector average is a function of the turbulence intensity. A relationship has been developed that relates the turbulence intensity to the difference between vector and scalar averages (6). The long-term predicted wind speeds will therefore be adjusted to reflect an equivalent scalar wind speed based on the turbulence intensity at the

In addition to wind data, the SODAR also records the ambient temperature, the precipitation and the wind speed as measured by an anemometer mounted on a ~3 m-high pole.

# SODAR Data Filters and Data Quality Checks

The next section describes the SODAR data filtering that was applied to the data at both the pre-processed and post-processed stages. The main function of these filters was to remove spurious data caused by high levels of ambient or electrical noise and to ensure good quality data.

# **Pre-processing SODAR Filtering**

When the SODAR collects data, there are four initial criteria that must be met in order for the data to be considered valid. First, the signal-to-noise ratio (SNR) is calculated at each height and if it is found to be below the user-defined minimum then the data is discarded. Next, the amplitude of the signal is calculated and the data is removed if it is below the minimum allowed amplitude.

The third criterion is called the consensus check. Once the ten-minute interval is complete, there will be  $\sim 150$  data samples (Doppler shifts) in each direction. The average Doppler shift is calculated in each direction and if, over that time interval, a data sample has a Doppler shift beyond the range of the average Doppler shift plus or minus the "consensus" (default = 100 Hz), then the data point is removed.

Finally, if, over the ten-minute interval, there is less than the minimum percent of valid data points (default = 15%) then the data for that ten-minute interval is considered invalid and is removed from the data set (5).

# **Echo Rejection Algorithm**

In addition to the pre-processing SODAR data filtering described above, the manufacturer has included an optional echo rejection algorithm which is designed to

minimize the effect of echoes caused by ground clutter. This option was enabled throughout the SODAR operation at Dartmouth.

Ground clutter is defined as trees, buildings, bushes or any stationary object surrounding the SODAR that could reflect the signal at a zero Doppler shift. When echoes occur in this way, the measured wind speed is biased low since the SODAR will interpret the zero Doppler shift as zero wind speed. Echoes from ground clutter impact the lower range gates more significantly than the higher range gates.

Ideally, the SODAR should be situated in an area void of ground clutter. When this is not possible, however, there are several steps that can be taken to minimize the effect of ground clutter. First, if the SODAR is oriented in such a way to direct the SODAR beams away from the ground clutter, the degree of echo contamination is lessened. Also, it has been found that if the SODAR can be raised to a higher elevation (for example, to the roof of a building) then the echoes have less of an impact. Finally, if ART's echo rejection algorithm is employed then the negative bias caused by echoes is greatly reduced.

The echo rejection option is a built-in function in the ART Model VT-1s and can be enabled at the user's discretion. The algorithm works by comparing the amount of spectral energy at the zero Doppler shift to spectral energy at other frequencies. If there is sufficient energy at a frequency other than the zero-shift, then the wind speed is calculated at this frequency and the energy at the zero-shift is ignored. It has been found in previous data sets that the echo rejection option is very effective at lessening the effects of ground clutter contamination.

### **Post-processing SODAR Filtering**

Once the wind speeds had been measured by the SODAR, additional filters were applied to the data. These filters were designed by comparing SODAR measurements to anemometer readings and determining appropriate cut-offs for removing erroneous data. These filters included the following:

- Maximum W turbulence intensity (W speed / Vector Wind Speed)
- Maximum U and V turbulence intensity (U or V speed / Vector Wind Speed)
- Minimum and maximum W wind speed (normalized by vector wind speed)
- Noise filter
- Shear filter

#### **Turbulence Intensity Filters**

The maximum W turbulence intensity used in the filtering was 0.4 and the maximum U and V turbulence intensity applied was 0.9. These values have shown to remove invalid measurements while retaining the majority of good data.

#### **Vertical (W) Wind Speed filter**

Minimum and maximum normalized W wind speeds were also defined based on

comparisons between SODAR and anemometry data. The minimum and maximum values used in the filtering algorithm were –0.12 and 0.16, respectively.

#### **Noise filter**

At past sites, there have been occurrences of extraneous noise entering the system which can contaminate the SODAR signal. The noise filter was designed to remove these erroneous data averages. Mention whether sources of extraneous noise were insignificant at the site.

The noise algorithm compares the calculated wind speed at each height to the wind speed measured by the anemometer (mounted on a 3 m pole). At each time step, the average difference between the SODAR (at each height) and the anemometer are calculated using the measured differences from the most recent five time steps. If the difference, at that time step, is greater than the average difference plus 4 m/s, then the data is discarded. Mention whether or not this filter had an impact on the data.

$$(Avg\ Difference)_{height} = \left(\frac{(Diff_{t-5} + Diff_{t-4} + Diff_{t-3} + Diff_{t-2} + Diff_{t-1})}{5}\right)_{height}$$

$$If\ (Diff_t)_{height} > (Avg\ Difference + 4)_{height}\ Then\ Discard$$

#### Shear filter

Finally, a shear filter was applied to the data. This filter was developed after it was observed that, even after applying the other filters, a significant amount of scatter existed when plotting SODAR versus anemometer data. It has been found that at sites where ground clutter is present, echoes tend to contaminate the signal and bias the wind speed low, particularly at lower range gate heights. It has also been observed that at higher heights, the returning signal has a lower amplitude and it becomes increasingly difficult for the SODAR to accurately distinguish signal from noise. Finally, when comparing SODAR to tower data, the highest correlation coefficients are typically found at SODAR heights between 40 m and 80 m.

Based on these observations, the shear filter was designed with the following algorithm:

- 1) The average wind speed is calculated at 70 m, using wind speeds at 60, 70 and 80 m. This is called the true wind speed at 70 m.
- 2) It then compares the wind speed at every height to the true 70 m wind speed.
- 3) The shear power law exponent, alpha, is calculated at each height using the 70 m wind speed as the datum. The following equation shows the wind shear power law expression where U is wind speed [m/s], z is height,  $z_r$  is the reference height and  $\alpha$  is the power law exponent.

$$\frac{U(z)}{U(z_r)} = \left(\frac{z}{z_r}\right)^{\alpha}$$

4) If alpha is greater than the user-defined maximum shear exponent then the data point is removed

- 5) If alpha is less than the user-defined minimum shear exponent then the data point is removed.
- 6) If the 60 m or 80 m data point had been deleted due to shear, then the 70 m data point is also removed.

When designing this filter, it had to be decided what alpha limits should be specified. To answer this question, several tall tower data sets were analyzed. The power law exponent, alpha, was calculated at each ten minute interval between the lower and upper height for each of the tall tower data sets. For each data set, day and night histograms were calculated and the minimum alphas were selected such that 2.5% of the alphas were less than the minimum. The maximum alphas were defined at an alpha where approximately 2.5% of the alphas were greater. Table 1 lists the five tall tower sets and the range of acceptable alphas. As shown, for more complex and forested terrain, the range of acceptable alphas are relatively wide. Conversely, the range of acceptable alphas is much narrower for the offshore tower (Cape Wind). This trend is logical since more wind shear will be present (i.e. higher alpha) when more obstacles are present to slow down the wind. For the Dartmouth data set, the alpha limits based on the Hull WBZ tall tower were used in the shear filter since the site is similar.

**Table 1: Summary of Tall Tower Alpha Limits** 

Site	Site Description	Day Alpha Minimum	Day Alpha Maximum	Night Alpha Minimum	Night Alpha Maximum
Nantucket, MA	Coastal	-0.2	0.7	-0.3	0.8
Hull WBZ, MA	Coastal / Complex terrain	-0.5	0.8	-0.3	0.9
Hatfield, MN	Onshore: flat with no trees	-0.5	0.9	-0.5	1.1
Isabella, MN	Onshore: forested	-0.3	1	-0.5	1.2
Cape Wind site, MA	Offshore	-0.2	0.6	-0.2	0.6

# SODAR Operation during times of precipitation

Since the SODAR measures the speed of moving volumes encountered in the atmosphere, precipitation will usually lead to incorrect wind speed measurements. The effect of precipitation is most evident in the W (vertical) direction, since precipitation obviously falls in this direction. A precipitation gauge was mounted on the SODAR unit and the data acquisition control system ensured that SODAR data was not collected during times of precipitation.

# **Data Analysis Methodology**

The following section outlines the approach taken in analyzing the Dartmouth SODAR data. Since the SODAR data alone was not sufficient to predict long-term wind speeds due to the limited data collection period and gaps in the data, an MCP algorithm was used with long-term anemometer data from the BUZM3 buoy to develop an estimate of the expected wind resource. Also, tower data from the ORR High School in Mattapoisett was used to validate the SODAR data. The steps taken in analyzing the Eastham data are described below.

# 1) SODAR data was analyzed and compared to 49 m anemometer data collected at the ORR High School in Mattapoisett, MA.

The correlation coefficient, average ratio and standard deviation of the ratio of SODAR to an emometer data were determined at each range gate.

# 2) Based on the comparison between the SODAR data and anemometer data, the valid range gates for the SODAR data set were determined.

After examining the correlation coefficient and ratio between the SODAR and anemometer data, a range of heights at which the data is valid was determined. This approach was taken because, as mentioned, if ground clutter is present, data at lower height can be contaminated which can lead to incorrect estimations of wind shear. Also, at higher heights, the reflected strength of the SODAR signal can become weaker and it becomes increasingly difficult for the SODAR to distinguish between signal and noise. The near-by tower data served as a guide in selecting the valid height ranges of the SODAR data.

# 3) The MCP algorithm was used with wind data from the BUZM3 buoy as the reference site to predict long-term wind speeds.

Measure-Correlate-Predict (MCP) is a technique used to predict the wind resource at a target site using long-term data at a reference site. The method used in this report is discussed in Reference 4. The site at Dartmouth was the target site and the anemometer data measured on the BUZM3 buoy was used as the reference site. A relationship was developed between the target and reference site based on the ratio of the wind speed standard deviations. Based on this relationship, a predicted long-term wind speed at a range of heights at Dartmouth was found.

### 4) The predicted long-term wind speeds were adjusted to account for the lowbias due to volume and vector averaging.

SODAR measurements tend to be lower than those of an anemometer and two main reasons for this are: vector averaging and volume averaging. These will be explained in more detail later in the report. After MCP, the predicted wind speeds at all heights were adjusted to reflect the bias.

# **Summary of Data Collection**

#### Location and Duration of Data Collection Site

RERL's SODAR unit #2 was deployed at the Darmouth inactive landfill in Massachusetts for two separate periods to collect wind data. Data was collected for the first period beginning on November 14<sup>th</sup>, 2007. A blown fuse halted data collection in the beginning of 2008 which was repaired on January 4<sup>th</sup>, 2008. The first data collection period ended on January 24<sup>th</sup> 2008.

The SODAR was then deployed again in Dartmouth from March 14<sup>th</sup> to May 30<sup>th</sup>, 2008. Figures 1 and 2 show maps of the location of the Dartmouth SODAR site. Figure 3 shows the SODAR at the Dartmouth landfill site.

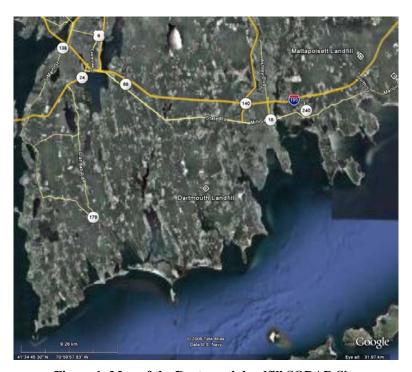


Figure 1: Map of the Dartmouth landfill SODAR Site



Figure 2: Map of the Dartmough SODAR Site (zoomed)



Figure 3: SODAR unit #2 at Dartmouth, MA

Once the SODAR data was collected, its validity had to be checked by comparing it to near-by anemometer data. Describe near-by tower data. The data collected at this tower was used to validate the SODAR data. Figure 4 shows a map of the Dartmouth site relative to the tower site. The distance between the Dartmouth landfill and ORR High School sites was 13 miles (21 km).

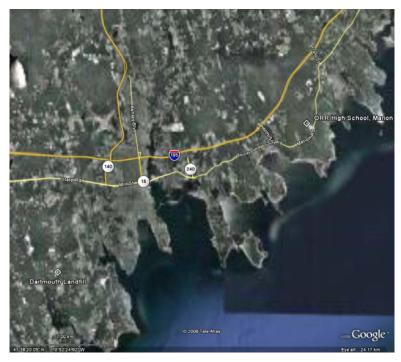


Figure 4: Map of Dartmouth landfill and ORR High School tower site

After the SODAR data was validated, an MCP algorithm was used to estimate the long-term wind speed. The long-term data set used as the reference site was from a NOAA buoy in Buzzards Bay and wind data collected since 1997 was used in the MCP analysis. The distance from the Dartmouth site to the buoy was 13 miles (21 km). Figure 4 shows a map of the Dartmouth site relative to the buoy location.



Figure 5: Map of Dartmouth and Long-term Location

# **Determining Range of Valid SODAR data**

The following section presents the results of the SODAR data analysis, which was conducted to determine the valid data that would be used in the MCP algorithm. The validity of lower heights can be compromised due to echo contamination, resonance or noise. At upper heights, the returning signal is less strong and it sometimes becomes difficult for the SODAR to distinguish between signal and noise. The SODAR data was therefore compared to the meteorological tower data from the Old Rochester Regional (ORR) High School in Mattapoisett and the range of valid SODAR data was determined.

The wind data was analyzed by plotting:

- Time series of SODAR data at 30 m, 60 m and 90 m
- Percent of valid data versus height
- Time series of SODAR (at 50 m) and tower data (at 49 m)
- Cross-correlation between the SODAR and tower data (at 49 m) versus height
- Average Ratio of SODAR to tower data (at 49 m) versus height
- Standard deviation of ratio of SODAR to tower data (at 49 m) versus height

## Summary of Dartmouth landfill SODAR data

The SODAR was placed at the Dartmouth landfill site from November 14<sup>th</sup> 2007 to January 24<sup>th</sup> 2008 and from March 14<sup>th</sup> to May 30<sup>th</sup> 2008. Figure 6 shows the time series of the SODAR data at 30 m, 60 m and 90 m for the time period.

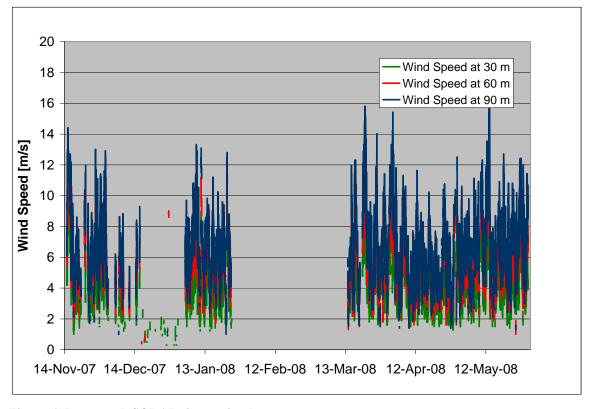


Figure 6: Dartmouth SODAR time series data

Figure 7 depicts the percent of valid data collected during this time after applying all filters.

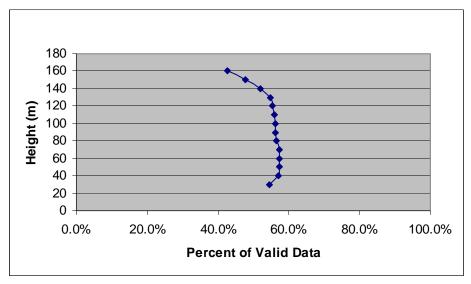


Figure 7: Percent of valid data

Next, data from the SODAR at 50 m was plotted in Figure 8 with the ORR tower data (at 49 m) versus time. Because of the amount of data collected and also because of the good correlation between the data sets, it is difficult to distinguish between the curves.

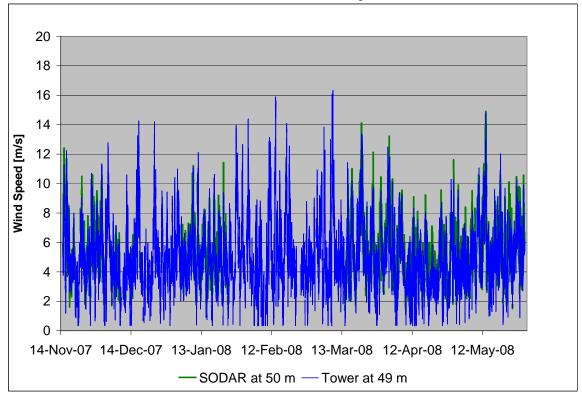


Figure 8: Dartmouth SODAR vs ORR Met Tower Time Series

The cross-correlation coefficients between the SODAR and the tower data and between

the SODAR and the ORR tower were calculated at each height and are shown in Figure 9. The highest correlation occurs at the height of the tower as expected.

When determining the heights of valid data, the correlation coefficient was used as an indicator of ground clutter contamination. In Figure 8, one would expect a high correlation between the SODAR and the tower at lower heights (i.e. closer to the anemometer height of 49 m). One would also expect the correlation coefficient to decrease at higher heights as the distance between the SODAR and anemometer measurement was increased.

Based on the correlation coefficient, the minimum height of valid data was determined to be 40 m. The drop in correlation for the 30 m measurement seems to indicate that ground clutter may be affecting the data.

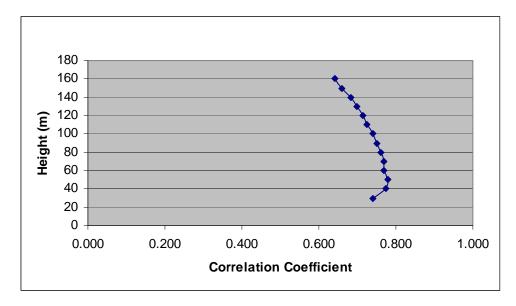


Figure 9: Dartmouth and 49 m ORR Tower Correlations vs. Height

Next, the ratio between the SODAR data and the ORR tower data was examined. Figure 10 shows the ratio of SODAR data at 50 m to the 49 m ORR tower data. If the two sites were perfectly correlated and had the same average wind speed, one would expect very little scatter and the majority of the points should lay around 1.0. If echo contamination was an issue, one would observe a significant amount of data points with very low ratios, particularly at lower wind speeds.

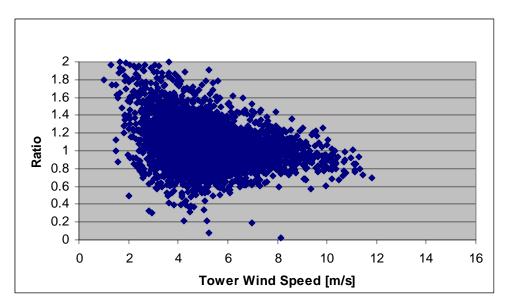


Figure 10: Ratio of SODAR 50 m / ORR 49 m

The average ratios and the standard deviation of the ratios were then calculated at each height and are plotted in Figures 11 and 12. The average ratio plot illustrates how the average wind speed at the Dartmouth site, at a range of heights, compared to the average wind speed at ORR at 49 m. As expected, the average ratio increased with height.

The standard deviation plot shows how much scatter was present in the ratio plots for each height. One would expect a larger standard deviation at higher heights, since the distance between the measurement points becomes larger. Figure 12 shows the standard deviation increasing with height up to the full height of valid data. Based on this analysis, the maximum height of valid data was determined to be 160 m.

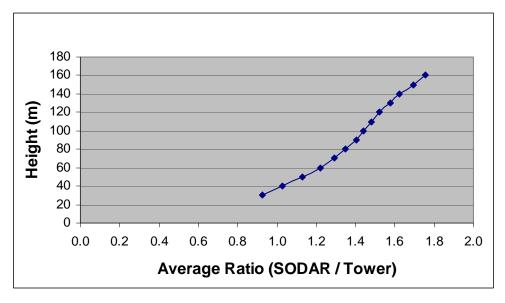


Figure 11: Average Ratio of Dartmouth SODAR to ORR met tower (49 m)

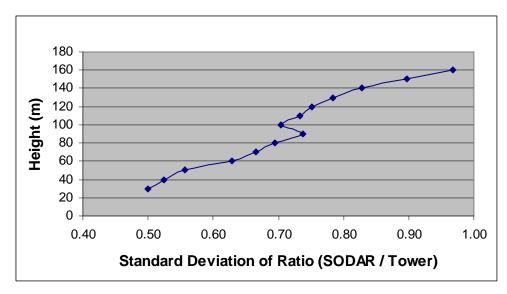


Figure 12: Standard Deviation of Ratio of Dartmouth SODAR to ORR met tower

Table 2 summarizes the data analysis when comparing the Dartmouth SODAR to the ORR 49 m tower:

Table 2: Summary of SODAR Comparison to ORR Tower

	Height	30	40	50	60	70	80	90	100	110	120	130	140	150	160
	Averages:	0.93	1.03	1.13	1.22	1.29	1.35	1.40	1.44	1.48	1.52	1.58	1.62	1.69	1.76
	CorrCoeff	0.74	0.77	0.78	0.77	0.77	0.76	0.75	0.74	0.73	0.72	0.70	0.68	0.66	0.64
l	Stdev of Ratio	0.50	0.52	0.56	0.63	0.66	0.70	0.74	0.70	0.73	0.75	0.78	0.83	0.90	0.97

Based on this comparison between the SODAR data and the ORR met tower data, the valid height range of SODAR data was found to be from 40 m to 160 m.

#### MCP Prediction for Dartmouth Site Using BUZM3 Data

Once the valid height ranges had been selected, the MCP algorithm was carried out. Since the tower that were used as a comparison to the SODAR data had approximately 2 years of data, another long-term reference site was needed as an input into the MCP algorithm. The reference site used was from the BUZM3 buoy located in Buzzards Bay (41°23'48" N 71°2'0" W). An anemometer is mounted at a height of 24.8 m above seat level and historical wind data since 1997 is used. When conducting an MCP analysis, it is best to use full-years of long-term data therefore data from may 13<sup>th</sup> 1997 to May 13<sup>th</sup> 2007 were used.

After conducting the MCP analysis, the predicted wind speeds were adjusted to account for bias due to both volume averaging and vector averaging. Volume averaging means that the SODAR measures wind speed over a volume for every height of interest (range gate). If the wind speeds vary significantly within that volume then the predicted wind speed can be skewed. This is of particular importance at sites with high wind shear. At

such sites, the predicted wind speed will be biased low by a SODAR. The extent of the underprediction is a function of height and of the power law shear exponent, alpha. At Dartmouth, the average alpha exponent was found to be 0.339. Using an in-house program coded in Visual Basic, the percent error was found at each range gate as shown in Table 3 below.

**Table 3: Volume Average Percent Error** 

Height,	Volume
m	average bias
30	-3.58%
40	-1.87%
50	-1.16%
60	-0.80%
70	-0.58%
80	-0.44%
90	-0.35%
100	-0.28%
110	-0.23%
120	-0.19%
130	-0.16%
140	-0.14%
150	-0.12%
160	-0.11%

As previously mentioned, the SODAR measures a vector averaged wind speed where as an anemometer measures a scalar averaged wind speed. The scalar average will always be greater than the vector average (typically 1-2 % higher) and the difference between the two is a function of the turbulence intensity. A relationship was developed that relates the ratio of the scalar and vector wind speeds to the turbulence intensity and is shown in Figure 13 below (6) where  $U/U_a = Vector Wind Speed / Scalar Wind Speed$ .

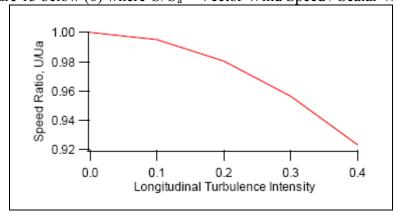


Figure 13: Effect of vector averaging on wind speed ratio, U/U<sub>a</sub>, as a function of turbulence intensity

Longitudinal turbulence intensity is measured by anemometers and is defined as the standard deviation of the horizontal wind speed divided by the average horizontal wind speed over a ten minute period. Based on the ORR met tower data, the average

turbulence intensity was found to be 0.233. A speed ratio of 0.98 corresponding to a turbulence intensity of approximately 0.23 is shown in Figure 13. This translates into a 2% low bias due to vector averaging.

Long-term wind speed predictions were made at every height between 30 m and 160 m (at 10 m intervals) and were adjusted to account for vector averaging and volume averaging. Table 6 shows the predicted long-term wind speeds. The predicted Weibull parameters, k and c, are presented and their significance will be explained later in this section. The uncertainty of the MCP analysis is also shown in the table. This uncertainty is associated only with the MCP portion of the analysis and is not the overall uncertainty of the wind speed.

**Table 4: Dartmouth Long-term Wind Speed Prediction Results** 

Height [m]	Corrected estimated wind speed [m/s]	Uncertainty of MCP [m/s]	Estimated k	Estimated c
40	4.75	1.64	2.58	5.25
50	5.18	1.71	2.73	5.75
60	5.58	1.83	2.85	6.21
70	5.88	1.94	2.86	6.56
80	6.14	2.15	2.85	6.87
90	6.36	2.51	2.80	7.12
100	6.56	2.62	2.73	7.35
110	6.75	2.72	2.68	7.57
120	6.90	2.86	2.63	7.75
130	7.15	2.76	2.64	8.03
140	7.30	2.57	2.59	8.20
150	7.57	2.54	2.61	8.52
160	7.84	2.74	2.64	8.82

The predicted wind speed is shown for each height as well as the estimated standard deviation. The Weibull probability density function (PDF) parameters, k and k, were also estimated at each height. A PDF provides a statistical representation of the wind resource at a site. The k parameter is referred to as the shape factor and the k parameter is called the scale factor. The shape factor determines the shape of the peak in the PDF and the scale factor is related to the average mean speed. A typical value for the shape factor is 2.0 and a higher value implies that there is less variation in the wind speeds at the site.

Weibull PDF: 
$$P(U) = \left(\frac{k}{c}\right) \left(\frac{U}{c}\right)^{k-1} \exp \left[-\left(\frac{U}{c}\right)^{k}\right]$$

#### **Dartmouth Uncertainty Analysis**

Throughout the process of estimating long-term wind speeds, several sources of error were introduced and must be accounted for. The following section describes each source of significant error, how the error was quantified and then compiled to determine the expected range of uncertainty. The end result is a range of wind speeds around the predicted mean wind speed that can be expected at Dartmouth. The percentage uncertainty values are the standard deviation divided by the mean value. In other words, the uncertainty range is representative of the expected standard deviation surrounding the predicted mean wind speed. Also, a P90 wind speed is given which represents the minimum average wind speed that can be expected at Dartmouth with 90% confidence.

The significant sources of uncertainty in this analysis included:

- 1) Uncertainty of SODAR Wind Speed, δU<sub>1</sub>
- 2) Uncertainty of MCP Analysis,  $\delta U_2$
- 3) Inter-annual Variability Uncertainty of Long-term Data, δU<sub>3</sub>

All the error sources (%) were combined into one equivalent uncertainty using the following equation:

$$\delta U = \sqrt{\delta U_1^2 + \delta U_2^2 + \delta U_3^2}$$

#### **Uncertainty of SODAR Measurement (δU<sub>1</sub>)**

The first source of error that was considered was the uncertainty of the SODAR. The manufacturer of the SODAR claims that the horizontal wind speed measurements have an accuracy of  $\pm$  0.25 m/s and the vertical wind speed is accurate to  $\pm$  0.04 m/s (5). Based on the relationship between the horizontal and vertical wind speed components, the overall uncertainty in the SODAR measurement is  $\pm$  0.282 m/s. At each range gate, the SODAR wind speed uncertainty of  $\pm$  0.282 m/s was converted to a percentage uncertainty (i.e. % uncertainty = (0.282 / Mean Wind Speed) x 100).

#### **Uncertainty of MCP Analysis (δU<sub>2</sub>)**

The MCP algorithm estimates the long-term wind speed at a target site based on the relationship of the wind speeds at the target site and a reference site. In this case, the target site was the Dartmouth SODAR and the reference site was the BUZM3 buoy. In the algorithm, a standard deviation was determined which quantified the uncertainty in the predicted long-term wind speed at the target site. An uncertainty was determined at each height at the Dartmouth site and this was representative of the uncertainty in the MCP analysis [4].

#### Inter-annual Variability Uncertainty of Long-term Data (δU<sub>3</sub>)

The next source of uncertainty is the inter-annual variability uncertainty, which arises

since the wind speed at a given site will vary from year to year. Typically, 20 years of data is considered to be sufficient to capture all inter-annual variability. With a shorter data set, there is uncertainty about whether the predicted wind speed is in fact representative of the long-term wind speed at that site. To quantify this error, the following equation can be used [2]:

$$\delta U = \frac{6\%}{\sqrt{N}}$$

where :  $N = Length \ of \ Data \ Set \ in \ Years$ 

Since 10 years of data from the buoy was used in this analysis, the inter-annual variability uncertainty is 1.9 %.

#### **Summary of Uncertainty Analysis**

Table 5 shows the predicted wind speeds at the site at Dartmouth along with the range of expected wind speeds incorporating all the error sources. The predicted P90 wind speed is also shown at each height which represents the minimum average wind speed that can be expected with 90% confidence.

Table 5: Dartmouth Predicted Wind Speeds, Expected Ranges and Expected P90 Wind Speed

	Predicted wind					P90 wind
Height	speed	Total unc	ertainty	Min	Max	speed
[m]	[m/s]	[%]	[m/s]	[m/s]	[m/s]	[m/s]
40	4.75	8.18	0.39	4.36	5.14	4.41
50	5.18	7.68	0.40	4.78	5.58	4.83
60	5.58	7.28	0.41	5.17	5.99	5.22
70	5.88	7.02	0.41	5.47	6.29	5.52
80	6.14	6.84	0.42	5.72	6.56	5.78
90	6.36	6.73	0.43	5.93	6.79	5.99
100	6.56	6.60	0.43	6.13	6.99	6.18
110	6.75	6.48	0.44	6.31	7.18	6.37
120	6.90	6.40	0.44	6.46	7.34	6.52
130	7.15	6.23	0.45	6.70	7.59	6.76
140	7.30	6.12	0.45	6.85	7.74	6.91
150	7.57	5.96	0.45	7.12	8.02	7.18
160	7.84	5.84	0.46	7.39	8.30	7.45

The long-term expected wind speed at the Dartmouth landfill site at 80 m was found to be  $6.14 \pm 0.41$  m/s. Figure 14 shows the predicted wind shear profile at the Dartmouth site along with the expected range of uncertainty. The error bars represent a 68 % uncertainty (i.e. one standard deviation of a normal distribution). One can then estimate with 68 % confidence that the long-term wind speed at a given height will fall within the error bars.

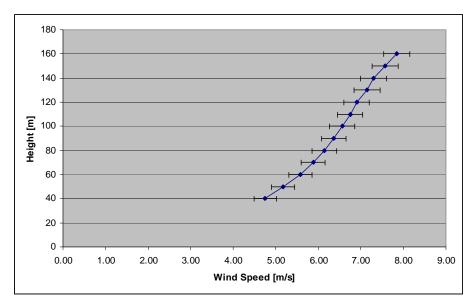
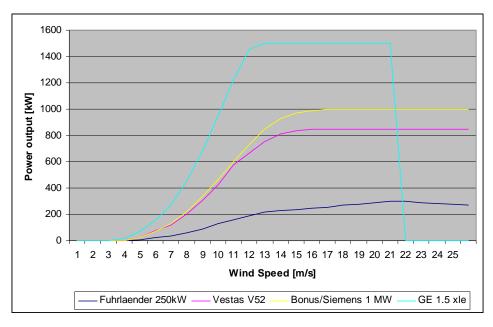


Figure 14: Dartmouth Wind Shear Profile with Uncertainty Range

## **Capacity Factor Calculation**

Finally, using the predicted mean wind speeds, the expected capacity factor was calculated for a few turbines of different rated power at their respective representative hub heights. The capacity factor is defined as the actual annual wind energy output divided by the rated wind turbine output.

The power curve used in the capacity factor calculation is shown in Figure 15.



**Figure 15: Wind Turbine Power Curves** 

The capacity factor of a wind turbine at a given site depends on the hub height, wind speed distribution at the hub height, the wind turbine power curve and any assumptions about down time and losses due to wake effects from upwind wind turbines, etc. No simple estimate of capacity factor at a site could take all of these effects and choices into account. Nevertheless, an estimate of the capacity factor of a wind turbine at this site is provided here to help the reader understand the order of magnitude of the wind resource at this site.

The estimates assume the turbines and hub heights as listed in Table 5 below together with the predicted long term mean wind speed as calculated previously. The wind speed probability distribution is assumed to be given by a Rayleigh distribution. The average wind turbine power is then estimated from:

$$\overline{P_W} = \int_{0}^{\infty} P_W(U) p(U) dU$$

where  $P_W(U)$  is the wind turbine power curve and p(U) is the wind speed probability distribution. The predicted power production was then multiplied by the expected losses that account for maintenance and icing. It was assumed that the loss factors due to maintenance and icing were each 0.95 and the combined loss factor was therefore 0.9025 (i.e.  $0.95^2$ ). Finally, the capacity factor is then calculated from:

$$CF = \frac{\overline{P_W}}{P_{rated}}$$

where  $P_{rated}$  is the rated capacity of the turbine.

Table 6 shows the predicted capacity factors at the respective hub heights for each of the turbines.

**Table 6: Dartmouth Capacity Factor Prediction** 

	Rated	Hub					
Turbine	Power	Height	Capacity F	actor	Capacity Factor with losses		
			Predicted wind P90 wind		Predicted wind	P90 wind	
	[kW]	m	speed	speed	speed	speed	
Fuhrlaender	250	50	0.16	0.14	0.13	0.10	
Vestas V52	850	49	0.16	0.14	0.12	0.10	
Siemens/Bonus	1000	60	0.18	0.15	0.14	0.12	
GE 1.5 xle	1500	80	0.30	0.26	0.24	0.21	

# **Summary and Discussion of Results**

One of RERL's SODARs was brought to the Dartmouth landfill to collect wind data for two separate periods between November 14<sup>th</sup> 2007 to May 30<sup>th</sup> 2008. The first period ended on January 24<sup>th</sup> and the second period began on March 4<sup>th</sup>.

The data collected at Dartmouth was compared to the ORR High School met tower data and the valid heights of SODAR data were found to be between 40 m to 160 m. Long-term wind speed data collected the BUZM3 buoy was then used as the reference data in MCP analysis. The long-term wind speed was then estimated and adjusted to account for vector and volume averaging effects at each height.

An uncertainty analysis was conducted and the expected range of long-term wind speeds was determined at each height. The estimated long-term wind speeds are shown in the Table 7, along with the expected range of uncertainty and the P90 wind speed.

**Table 7: Predicted Wind Speeds and Ranges of Uncertainty** 

	Predicted wind			P90 wind
Height	speed	Min	Max	speed
[m]	[m/s]	[m/s]	[m/s]	[m/s]
30	4.38	4.00	4.76	4.05
40	4.75	4.36	5.14	4.41
50	5.18	4.78	5.58	4.83
60	5.58	5.17	5.99	5.22
70	5.88	5.47	6.29	5.52
80	6.14	5.72	6.56	5.78
90	6.36	5.93	6.79	5.99
100	6.56	6.13	6.99	6.18
110	6.75	6.31	7.18	6.37
120	6.90	6.46	7.34	6.52
130	7.15	6.70	7.59	6.76
140	7.30	6.85	7.74	6.91
150	7.57	7.12	8.02	7.18
160	7.84	7.39	8.30	7.45

The expected wind speed at the Dartmouth at 80 m is 6.14 m/s and there is a 68% level of confidence that the average wind speed will be between 5.72 and 6.56 m/s.

Finally, using four representative turbines and their power curves, along with the predicted wind distribution, capacity factors were estimated at their respective hub heights. The capacity factor is defined as the actual annual wind energy output divided by the rated wind turbine output. Table 8 summarizes the predicted capacity factors at the turbine hub heights.

**Table 8: Summary of Estimated Capacity Factors at Dartmouth** 

	Rated	Hub					
Turbine	Power	Height	Capacity F	actor	Capacity Factor with losses		
			Predicted wind P90 wind		Predicted wind	P90 wind	
	[kW]	m	speed	speed	speed	speed	
Fuhrlaender	250	50	0.16	0.14	0.13	0.10	
Vestas V52	850	49	0.16	0.14	0.12	0.10	
Siemens/Bonus	1000	60	0.18	0.15	0.14	0.12	
GE 1.5 xle	1500	80	0.30	0.26	0.24	0.21	

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- 5) ART Model VT1 Sodar Manual Version 10.5, ART LLC, November 2004
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# WIND DATA REPORT

# Dartmouth, MA

March  $26^{th}$  2005 to July  $31^{st}$  2006

## Prepared for

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Massachusetts Division of Energy Resources

by

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#### **EXECUTIVE SUMMARY**

All the work presented in this Wind Data Report including installation and decommissioning of the meteorological tower and instrumentation, and the data analysis and reporting was preformed by the Renewable Energy Research Laboratory (RERL) at the University of Massachusetts, Amherst.

Wind monitoring at Dartmouth commenced on March 26<sup>th</sup>, 2005, and the station was removed in September, 2006. Wind speed and direction are measured at three heights: 50 m, 38 m and 20 m.

This final report presents data for the entire duration of the wind monitoring campaign at Dartmouth. While the tower was not removed until September, because of problems with the data card, there is no wind data after July 31, 2006. Thus, there is data for the Dartmouth site from March 26, 2005 until July 31, 2006. The data is not continuous over this period, however, as a problem with the logger caused there to be no data for the month of December, 2005.

Because of seasonal variations in the wind speed, wind data is typically reported in integer year intervals. Thus, while there are approximately 16 total months of data, all the yearly summary statistic provided, and all graphs except for the time series graph and monthly average graph, are from the period of August 1, 2005 until July 31, 2006, which covers exactly one year. Once again, it must be emphasized that all the data from December, 2005 is missing, and so the yearly statistics and graphs are missing the December, 2005 data.

During the period of August 1, 2005 to July 31, 2006, the mean recorded wind speed at 50 meters was 4.8 m/s (10.6 mph \*) and the prevailing wind direction at 50 m was SW. The gross data recovery percentage (the actual percentage of expected data received) was 90.7 % and the net data recovery percentage (the percentage of expected data which passed all of the quality assurance tests) was 89.1%. The vast majority of this missing data was due to the logger failure in December, 2005.

Additional information about interpreting the data presented in this report can be found in the Fact Sheet, "Interpreting Your Wind Resource Data," produced by RERL and the Massachusetts Technology Collaborative (MTC). This document is found through the RERL website:

http://www.ceere.org/rerl/about\_wind/RERL\_Fact\_Sheet\_6\_Wind\_resource\_interpretation.pdf

\*1 m/s = 2.237 mph.

## **SECTION 1 - Station Location**

The site is located close to the drainage pits in the Dartmouth Water Treatment Facility premises. The site elevation is 9 m above sea level. The location of the tower base is at 41.590°N, 70.998°W (WGS84/NAD83).

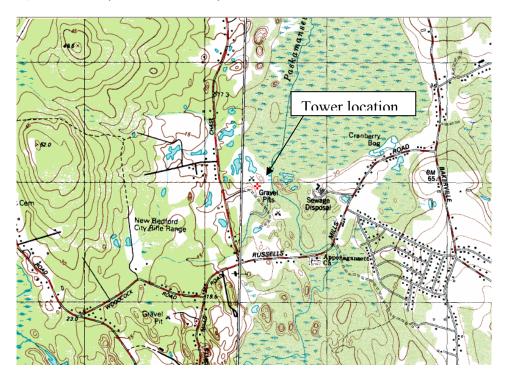


Figure 1 - Dartmouth Site Location

Source: www.topozone.com.

# **SECTION 2 - Instrumentation and Equipment**

Wind monitoring equipment is mounted on a standard Second Wind 50 m tall 6-inch diameter tilt-up guyed tower. Wind vanes and anemometers are located at three heights on the tower: 50 m, 38 m, and 20 m. Redundant anemometers are also positioned at 50 m and 38 m.

Additional equipment and models:

- NRG model Symphonie Cellogger
- 5 #40 Anemometers, standard calibration (Slope 0.765 m/s, Offset 0.350 m/s)
- 3 #200P Wind direction vanes

- Lightning rod and grounding cable
- NRG 11S temperature Sensor

The data from the Symphonie logger was mailed to the University of Massachusetts, Amherst on a regular basis. The logger samples wind speed and direction once every two seconds. These are then combined into 10-minute averages, and along with the standard deviation for those 10-minute periods, are put into a binary file. These binary files are converted to ASCII text files using the NRG software BaseStation®. These text files are then imported into a database software program where they are subjected to QA tests prior to using the data.

## **SECTION 3- Data Collection and Maintenance**

The following maintenance/equipment problems occurred during the report period, and the following corrective actions taken:

The logger was replaced at the end of December, 2005.

The tower was removed from the site in September.

#### **Data Statistics Summary**

Date	Mean Wind Speed	Max Wind Speed	Prevailing Wind Direction	Turbulence Intensity	Mean Wind Speed	Max Wind Speed	Prevailing Wind Direction	Turbulence Intensity	Mean Wind Speed	Max Wind Speed	Prevailing Wind Direction	Turbulence Intensity	Shear Coefficient
Heights, units	50 m, [m/s]	50 m, [m/s]	50 m, []	50 m, []	38 m, [m/s]	38 m, [m/s]	38 m, []	38 m, []	20 m, [m/s]	20 m, [m/s]	20 m, []	20 m, []	50 m, 38 m
05-Apr	5.0	14.4	SW	0.22	4.4	13.1	SW	0.25	3.2	10.0	SW	0.33	0.51
05-May	4.7	14.2	NNE	0.23	4.2	12.9	NNE	0.27	3.0	9.9	N	0.34	0.53
05-Jun	4.1	10.2	SW	0.23	3.7	9.3	SW	0.27	2.7	7.2	SW	0.35	0.46
05-Jul	4.0	11.1	SW	0.22	3.5	9.9	SW	0.26	2.4	8.1	SW	0.35	0.54
05-Aug	3.8	11.5	SW	0.22	3.3	10.5	SW	0.26	2.2	8.3	SW	0.36	0.66
05-Sep	4.0	11.6	SW	0.20	3.4	10.7	SW	0.30	2.2	8.6	SSW	0.32	0.73
05-Oct	5.0	15.3	WNW	0.20	4.3	14.0	WNW	0.30	3.0	10.5	NE	0.34	0.72
05-Nov	5.1	13.9	SW	0.20	4.3	12.7	SW	0.30	3.0	9.9	SW	0.32	0.67
05-Dec	-	ı	-	-	-	-	-	-	-	-	-	-	-
06-Jan	5.2	14.8	SW	0.22	4.6	12.9	SW	0.25	3.4	10.6	SW	0.31	0.56
06-Feb	5.7	14.0	NW	0.22	4.9	13.2	NW	0.24	3.8	10.9	WNW	0.30	0.45
06-Mar	5.0	14.1	NW	0.22	4.4	13.0	NW	0.25	3.3	10.3	WNW	0.31	0.51
06-Apr	5.1	11.8	SW	0.21	4.5	10.6	SW	0.25	3.3	8.6	N	0.33	0.60
06-May	4.8	12.0	SW	0.23	4.2	10.9	SW	0.28	3.1	8.3	SW	0.35	0.65

06-Jun	4.3	11.6	SW	0.22	3.7	10.0	SW	0.27	2.7	7.3	SSW	0.35	0.67
06-Jul	4.3	11.2	SW	0.22	3.7	10.5	SW	0.26	2.6	8.0	SW	0.35	0.67
Aug 05 – Jul 06	4.8	15.3	sw	0.21	4.1	14.0	sw	0.27	3.0	10.9	sw	0.33	0.63

Wind data statistics in the table are reported when more than 90% of the data during the reporting period are valid. In cases when a larger amount of data is missing, the percent of the available data that are used to determine the data statistics is noted.

No measurement of wind speed can be perfectly accurate. Errors occur due to an emometer manufacturing variability, an emometer calibration errors, the response of an emometers to turbulence and vertical air flow and due to air flows caused by the an emometer mounting system. Every effort is made to reduce the sources of these errors. Nevertheless, the values reported in this report have an expected uncertainty of about  $\pm 2\%$  or  $\pm 0.2$  m/s, whichever is greater.

When data at multiple heights are available, shear coefficients,  $\alpha$ , have been determined. They can be used in the following formula to estimate the average wind speed, U(z), at height z, when the average wind speed,  $U(z_r)$ , at height  $z_r$  is known:

$$U(z)=U(z_r)\left(\frac{z}{z_r}\right)^{\alpha}$$

The change in wind speed with height is a very complicated relationship related to atmospheric conditions, wind speed, wind direction, time of day and time of year. This formula may not provide the correct answer at any given site. Nevertheless the calculated shear coefficient, based on measurements at two heights, can be used to characterize the degree of increase in wind speed with height at a site.

# **SECTION 4- Significant Meteorological Events**

There were no extreme metrological events in the period covered by this report. The highest wind speeds in the 16 months are less than 16 m/s as shown by the time series graph.

# **SECTION 5 - Data Recovery and Validation**

All raw wind data are subjected to a series of tests and filters to weed out data that are faulty or corrupted. Definitions of these quality assurance (QA) controls are given below under Test Definitions and Sensor Statistics. These control filters were designed to automate the quality control process and used many of the previous hand-worked data sets

made at UMass to affect a suitable emulation. The gross percentage of data recovered (ratio of the number of raw data points received to data points expected) and net percentage (ratio of raw data points which passed all QA control tests to data points expected) are shown below.

Gross Data Recovered [%]	90.7
Net Data Recovered [%]	89.1

#### **Test Definitions**

All raw data were subjected to a series of validation tests, as described below. The sensors tested and the parameters specific to each sensor are given in the Sensor Performance Report that is included in APPENDIX A. Data that were flagged as invalid were not included in the statistics presented in this report.

**MinMax Test:** All sensors are expected to report data values within a range specified by the sensor and logger manufacturers. If a value falls outside this range, it is flagged as invalid. A data value from the sensor listed in Test Field 1 (TF1) is flagged if it is less than Factor 1 (F1) or greater than Factor 2. This test has been applied to the following sensors (as applicable): wind speed, wind speed standard deviation, wind direction, temperature, and solar insolation.

**MinMaxT Test:** This is a MinMax test for wind direction standard deviation with different ranges applied for high and low wind speeds. A wind direction standard deviation data value (TF1) is flagged either if it is less than Factor 1, if the wind speed (TF2) is less than Factor 4 and the wind direction standard deviation is greater than Factor 2, or if the wind speed is greater than or equal to Factor 4 and the wind direction standard deviation is greater than Factor 3.

$$(TF1 < F1)$$
  
or  $(TF2 < F4 \text{ and } TF1 > F2)$   
or  $(TF2 \ge F4 \text{ and } TF1 > F3)$ 

**Icing Test:** An icing event occurs when ice collects on a sensor and degrades its performance. Icing events are characterized by the simultaneous measurements of near-zero standard deviation of wind direction, non-zero wind speed, and near- or below-freezing temperatures. Wind speed, wind speed standard deviation, wind direction, and wind direction standard deviation data values are flagged if the wind direction standard deviation (CF1) is less than or equal to Factor 1 (F1), the wind speed (TF1) is greater than Factor 2 (F2), and the temperature (CF2) is less than Factor 3 (F3). To exit an icing event, the wind direction standard deviation must be greater than Factor 4 (F4).

$$CF1 \le F1$$
 and  $TF1 > F2$  and  $CF2 < F3$ 

CompareSensors Test: Where primary and redundant sensors are used, it is possible to determine when one of the sensors is not performing properly. For anemometers, poor performance is characterized by low data values. Therefore, if one sensor of the pair reports values significantly below the other, the low values are flagged. At low wind speeds (Test Fields 1 and 2 less than or equal to Factor 3) wind speed data are flagged if the absolute difference between the two wind speeds is greater than Factor 1. At high wind speeds (Test Fields 1 or 2 greater than Factor 3) wind speed data are flagged if the absolute value of the ratio of the two wind speeds is greater is greater than Factor 2.

```
[ TF1 \leq F3 and TF2 \leq F3 and abs(TF1 - TF2) > F1 ] or [ (TF1 > F3 or TF2 > F3) and (abs(1 - TF1 / TF2) > F2 or abs(1 - TF2 / TF1) > F2) ]
```

#### **Sensor Statistics**

**Expected Data Points:** the total number of sample intervals between the start and end dates (inclusive).

**Actual Data Points:** the total number of data points recorded between the start and end dates.

**% Data Recovered:** the ratio of actual and expected data points (this is the *gross data recovered percentage*).

**Hours Out of Range:** total number of hours for which data were flagged according to MinMax and MinMaxT tests. These tests flag data, which fall outside of an expected range.

**Hours of Icing:** total number of hours for which data were flagged according to Icing tests. This test uses the standard deviation of wind direction, air temperature, and wind speed to determine when sensor icing has occurred.

**Hours of Fault:** total number of hours for which data were flagged according to CompareSensors tests. These tests compare two sensors (e.g. primary and redundant anemometers installed at the same height) and flag data points where one sensor differs significantly from the other.

**% Data Good:** the filter results are subtracted from the gross data recovery percentage to yield the *net data recovered percentage*.

## **SECTION 6 - Data Summary**

This report contains several types of wind data graphs. Unless otherwise noted, each graph represents data from the August, 2005 through July, 2006. Again, there is no data from December, 2005. The following graphs are included:

- Time Series 10-minute average wind speeds at a height of 50 m are plotted against time. The wind speed time series is shown in Figure 2.
- Wind Speed Distribution A histogram plot giving the percentage of time that the wind is at a given wind speed at a height of 50 m. The wind blows between 4-5 m/s for close to 22% of the time. The wind speed distribution is shown in Figure 3.
- Monthly Average A plot of the monthly average wind speed at a height of 50 m from April 2005 July 2006. This graph shows the trends in the wind speed over the year. The monthly average wind speed plot is shown in Figure 4. Data is missing from December 2005, when the logger was broken.
- Diurnal A plot of the average wind speed for each hour of the day at a height of 50 m. The hourly mean wind speed high occurs between 1 pm and 2 pm and the low occurs between 5 am and 6 am. The diurnal variation plot is shown in Figure 5.
- Turbulence Intensity A plot of turbulence intensity as a function of wind speed at a height of 50 m. Turbulence Intensity is calculated as the standard deviation of the wind speed divided by the wind speed and is a measure of the gustiness of a wind resource. Lower turbulence results in lower mechanical loads on a wind turbine. The turbulence intensity graph flattens out after 4 m/s. The turbulence intensity plot is shown in Figure 6.
- Wind Rose A plot, by compass direction showing the percentage of time that the wind comes from a given direction and the average wind speed in that direction at a height of 50 m. The wind blew most frequently from the Southwest over the course of the year. The wind rose plot is shown in Figure 7.

# **SECTION 7- Graphs**

Data for the wind speed histograms, monthly and diurnal average plots, and wind roses are included in APPENDIX B.

## **Wind Speed Time Series**

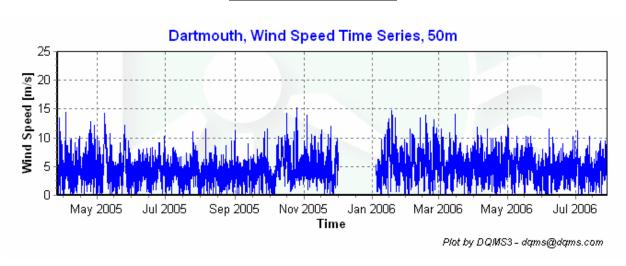


Figure 2 - Wind Speed Time Series, March 26, 2005 - July 31, 2006.

#### **Wind Speed Distributions**

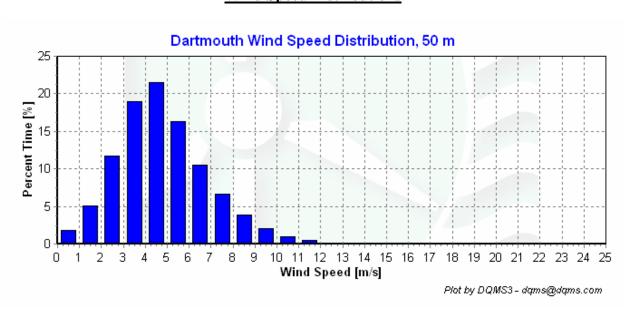


Figure 3 - Wind Speed Distribution, August 1, 2005 – July 31, 2006.

#### **Monthly Average Wind Speeds**

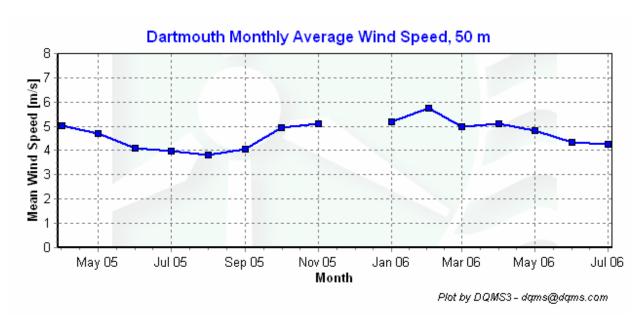


Figure 4 - Monthly Average Wind Speeds, April 1, 2005 - July 31, 2006.

## **Diurnal Average Wind Speeds**

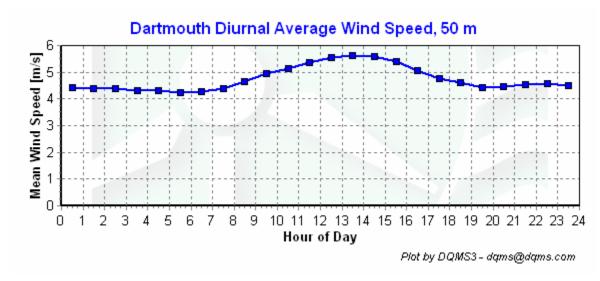


Figure 5 - Diurnal Wind Speed, August 1, 2005 - July 31, 2006.

## **Turbulence Intensities**

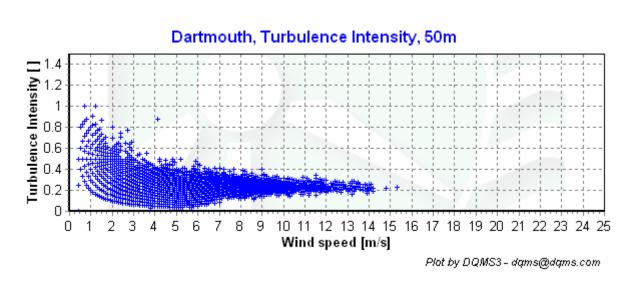


Figure 6 - Turbulence Intensity vs. Wind Speed, August 1, 2005 – July 31, 2006.

## **Wind Rose**

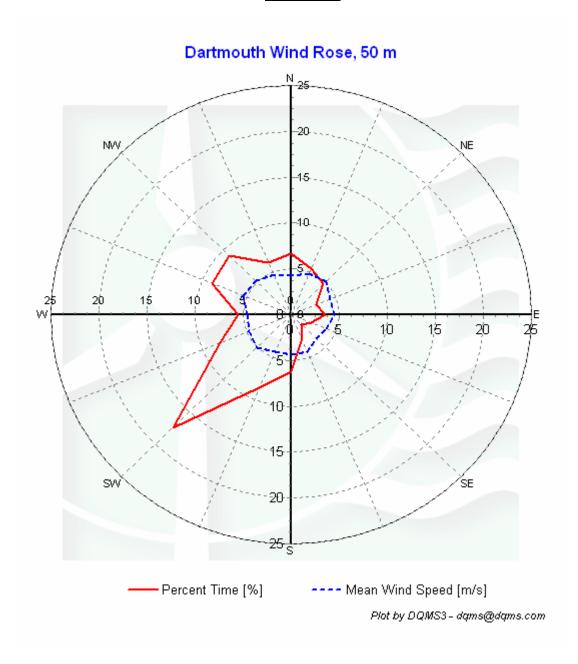


Figure 7 - Wind Rose, August 1, 2005 – July 31, 2006.

# **APPENDIX A – Sensor Performance Report**

## **Test Definitions**

Test Order	TestField1	TestField2	TestField3	CalcField1	CalcField2	TestType	Factor1	Factor2	Factor3	Factor4
1						TimeTest Insert	0	0	0	0
2	Etmp2aDEGC					MinMax	-30	60	0	0
3	Etmx2aDEGC					MinMax	-30	60	0	0
4	Etmn2aDEGC					MinMax	-30	60	0	0
5	EtmpSD2aDEGC					MinMax	-30	60	0	0
10	Anem50aMS					MinMax	0	90	0	0
11	Anem50bMS					MinMax	0	90	0	0
12	Anem38aMS					MinMax	0	90	0	0
13	Anem38bMS					MinMax	0	90	0	0
14	Anem20aMS					MinMax	0	90	0	0
15	Anem50yMS					MinMax	0	90	0	0
16	Anem38yMS					MinMax	0	90	0	0
20	AnemSD50aMS					MinMax	0	4	0	0
21	AnemSD50bMS					MinMax	0	4	0	0
22	AnemSD38aMS					MinMax	0	4	0	0
23	AnemSD38bMS					MinMax	0	4	0	0
24	AnemSD20aMS					MinMax	0	4	0	0
25	AnemSD50yMS					MinMax	0	4	0	0
26	AnemSD38yMS					MinMax	0	4	0	0
30	Vane50aDEG					MinMax	0	359.9	0	0
31	Vane38aDEG					MinMax	0	359.9	0	0
32	Vane20aDEG					MinMax	0	359.9	0	0
50	Turb50zNONE					MinMax	0	2	0	0
51	Turb38zNONE					MinMax	0	2	0	0
60	Wshr0zNONE					MinMax	-100	100	0	0
70	Pwrd50zWMS					MinMax	0	5000	0	0
71	Pwrd38zWMS					MinMax	0	5000	0	0
200	VaneSD50aDEG	Anem50yMS				MinMaxT	0	100	100	10
201	VaneSD38aDEG	Anem38yMS				MinMaxT	0	100	100	10
202	VaneSD20aDEG	Anem20aMS				MinMax	0	100	100	10
300	Anem50aMS	AnemSD50aMS	Vane50aDEG	VaneSD50aDEG	Etmp2aDEGC	Icing	0.5	1	2	10
301	Anem50bMS	AnemSD50bMS	Vane50aDEG	VaneSD50aDEG	Etmp2aDEGC	Icing	0.5	1	2	10
302	Anem38aMS	AnemSD38aMS	Vane38aDEG	VaneSD38aDEG	Etmp2aDEGC	Icing	0.5	1	2	10
303	Anem38bMS	AnemSD38bMS	Vane38aDEG	VaneSD38aDEG	Etmp2aDEGC	Icing	0.5	1	2	10
304	Anem20aMS	AnemSD20aMS	Vane20aDEG	VaneSD20aDEG	Etmp2aDEGC	Icing	0.5	1	2	10
400	Anem50aMS	Anem50bMS				CompareSensors	1	0.25	3	0
401	Anem38aMS	Anem38bMS				CompareSensors	1	0.25	3	0

500	Amax50aMS		MinMax	0	90	0	0
501	Amax50bMS	+ + + + + + + + + + + + + + + + + + + +	MinMax	0	90	0	0
502	Amax38aMS		MinMax	0	90	0	0
503	Amax38bMS		MinMax	0	90	0	0
504	Amax20aMS		MinMax	0	90	0	0
510	Amin50aMS		MinMax	0	90	0	0
511	Amin50bMS		MinMax	0	90	0	0
512	Amin38aMS		MinMax	0	90	0	0
513	Amin38bMS		MinMax	0	90	0	0
514	Amin20aMS		MinMax	0	90	0	0
520	Vmax50aDEG		MinMax	0	359.9	0	0
521	Vmax38aDEG		MinMax	0	359.9	0	0
522	Vmax20aDEG		MinMax	0	359.9	0	0
530	Vmin50aDEG		MinMax	0	359.9	0	0
531	Vmin38aDEG		MinMax	0	359.9	0	0
532	Vmin20aDEG		MinMax	0	359.9	0	0

# **Sensor Statistics**

Sensors	Expected Data Points	Actual Data Points	% Data Recovered	Hours Out of Range	Hours of Icing	Hours of Fault	% Data Good
Anem50aMS	52560	47649	90.656	0.167	167.5	0	88.742
AnemSD50aMS	52560	47649	90.656	0.167	167.5	0	88.742
Anem50bMS	52560	47649	90.656	0.167	161.667	0.167	88.807
AnemSD50bMS	52560	47649	90.656	0.167	161.667	0.167	88.807
Anem38aMS	52560	47649	90.656	0	150.167	28.833	88.613
AnemSD38aMS	52560	47649	90.656	0	150.167	28.833	88.613
Anem38bMS	52560	47649	90.656	0	187	1.833	88.501
AnemSD38bMS	52560	47649	90.656	0	187	1.833	88.501
Anem20aMS	52560	47649	90.656	0	95.167	0	89.57
AnemSD20aMS	52560	47649	90.656	0	95.167	0	89.57
Vane50aDEG	52560	47649	90.656	2.333	167.5	0	88.718
VaneSD50aDEG	52560	47649	90.656	2.333	167.5	0	88.718
Vane38aDEG	52560	47649	90.656	3.333	189.333	0	88.457
VaneSD38aDEG	52560	47649	90.656	3.333	189.333	0	88.457
Vane20aDEG	52560	47649	90.656	3.5	95.167	0	89.53
VaneSD20aDEG	52560	47649	90.656	3.5	95.167	0	89.53
Etmp2aDEGC	52560	47649	90.656	0	0	0	90.656
EtmpSD2aDEGC	52560	47649	90.656	0	0	0	90.656
Total	946080	857682	90.656	19	2427	61.667	89.066

# **APPENDIX B - Plot Data**

# **Wind Speed Distribution Data**

Bin Center Wind Speed [m/s]	Percent of Time [%]
0.5	1.76
1.5	5.03
2.5	11.69
3.5	18.91
4.5	21.51
5.5	16.32
6.5	10.48
7.5	6.64
8.5	3.82
9.5	2.09
10.5	0.96
11.5	0.47
12.5	0.17
13.5	0.12
14.5	0.03
15.5	0
16.5	0
17.5	0
18.5	0
19.5	0
20.5	0
21.5	0
22.5	0
23.5	0
24.5	0

Table 1 - Wind Speed Distribution, August 1, 2005 – July 31, 2006.

## **Monthly Average Wind Speed Data**

Date	10 min Mean [m/s]
Apr-05	5.04
May-05	4.7
Jun-05	4.1
Jul-05	3.98
Aug-05	3.82
Sep-05	4.04
Oct-05	4.96
Nov-05	5.1
Dec-05	-
Jan-06	5.2
Feb-06	5.73

Mar-06	4.97
Apr-06	5.12
May-06	4.83
Jun-06	4.33
Jul-06	4.27

Table 2 - Wind Speed Averages, 50m

# **Diurnal Average Wind Speed Data**

Hour of Day	Average Wind Speed [m/s]				
0.5	4.44				
1.5	4.40				
2.5	4.37				
3.5	4.29				
4.5	4.31				
5.5	4.25				
6.5	4.28				
7.5	4.39				
8.5	4.64				
9.5	4.94				
10.5	5.15				
11.5	5.38				
12.5	5.55				
13.5	5.63				
14.5	5.57				
15.5	5.40				
16.5	5.05				
17.5	4.75				
18.5	4.62				
19.5	4.43				
20.5	4.44				
21.5	4.53				
22.5	4.58				
23.5	4.52				

Table 3 - Diurnal Average Wind Speeds, August 1, 2005 – July 31, 2006.

## **Wind Rose Data**

Direction	Percent Time [%], 50 m	Mean Wind Speed [m/s], 50 m
N	6.68	4.27
NNE	5.46	4.81
NE	4.75	5.11
ENE	2.87	4.36
Е	3.56	4.47
ESE	2.24	3.93
SE	1.50	3.68
SSE	2.89	4.32
S	6.22	4.34
SSW	8.65	4.37
SW	17.42	5.03
WSW	7.96	4.79
W	5.56	4.58
WNW	8.89	5.45
NW	9.16	5.20
NNW	6.18	4.73

Table 4 - Wind Rose, Time Percentage and Mean Wind Speed by Direction, August 1, 2005 – July 31, 2006.

# APPENDIX B

# SITE INFORMATION

Date 3   PROJECT NAME:   Wind Turbines	Client N				ampshir lest Che on,			38	02301		t 1 of 2 JOB NUMBE	2 <b>Boring No.</b> T		TB-1
Date & Time Stands   Date & Time Completed   Total Hours Worked			1										Turbines	
Street				ilding					Date & Time S			e Completed	Total Hours	Worked
Depth Range   Sample   Depth Range   Respect   Depth Range   Respect   Depth Range   Respect					e & Tim	e: 3/8/	/11		3/7/11		3/8	3/11		
Sample   Depth Range   Greet   Depth Range   Greet   Depth Range   Greet   Depth Range   Greet   Depth Range   Depth Range   Greet   Depth Range   Depth Range   Greet   Depth Range									HELPER					
Number   Greet					Inspec	tor's Na	me (Print)	:			Inspector's	Company:		
S-1	Sample	Depth Range	Blow	Counts	per 6 li	nches	Recovery			Fio	ld Descript			Strata
S-2	Number	(Feet)	0-6	6-12	12-18	18-24	(inches)			rie	id Descript	1011		Changes
S-3	S-1	0-2	4	6	10	13	12	Dry,	medium dense	e, ligh	nt brown, FIN	E SAND		
S-3														
S-3				18										
S-3								38						
S-3 9-11 5 5 5 6 16  S-4 14-16 4 4 6 8 10  S-5 19-21 5 5 4 5 8  Wet, loose, light gray, COARSE SAND, trace gravel, some silt  Wet, loose, light gray, COARSE SAND, trace gravel, some silt  Wet, loose, light gray, FINE SAND  AUGER SIZE:  Cohesionless Soils (Sands, Gravels)  Cohesionless Soils (Sands, Gravels)  Relative Density   Penetration Resistance   Consistency   Penetration Resistance   Consistency   Penetration Resistance   CASING SIZE: Very Loose   Very Loose   Very Loose   Very Loose   Very Soft   0 - 2   Soft   2 - 4   Wedum Dense   10 - 30   Medium Stiff   4 - 8   Dense   30 - 50   Stiff   8 - 15   Very Siff   15 - 30   Dense   Over 50   Very Siff   15 - 30   Dense   Over 30   Over 30   Dense   Over 50   Very Siff   15 - 30   Dense   Over 50   Very Siff   15 - 30   Dense   Over 30   Over	S-2	4-6	8	10	8	6	2	Wet,	medium dens	se, CC	DARSE SAN	D AND GRA	VEL	
Net														
Net	24													
Net								1						
Net									*.I					
S-4	S-3	9-11	5	5	5	6	16	Wet	loose light br	own.	FINE SAND	trace silt		
S-4		0						1.0.,	10000, 119.11.01	J,	, , , , = 0, , , , e			
S-4		1												
S-4														
S-5									81					
S-5	C 4	14.16	4	4	6	0	10	Mot	loose light ar	OV C	OADSE SAN	ID trace are	uol	
S-5	5-4	14-16	4	4	0	0	10			ay, C	UARSE SAI	ND, trace gra	vei,	
S-6   24-26   4   8   8   7   16   Wet, medium dense, COARSE SAND, w/gravel   S-6   24-26   4   8   8   7   16   Wet, medium dense, COARSE SAND, w/gravel   S-6   24-26   4   8   8   7   16   Wet, medium dense, COARSE SAND, w/gravel   S-6   COARSE SAND, w/gravel   S-7   COAR								some	SIIT					
S-6   24-26   4   8   8   7   16   Wet, medium dense, COARSE SAND, w/gravel   S-6   24-26   4   8   8   7   16   Wet, medium dense, COARSE SAND, w/gravel   S-6   24-26   4   8   8   7   16   Wet, medium dense, COARSE SAND, w/gravel   S-6   COARSE SAND, w/gravel   S-7   COAR		+1												
S-6   24-26   4   8   8   7   16   Wet, medium dense, COARSE SAND, w/gravel   S-6   24-26   4   8   8   7   16   Wet, medium dense, COARSE SAND, w/gravel   S-6   24-26   4   8   8   7   16   Wet, medium dense, COARSE SAND, w/gravel   S-6   COARSE SAND, w/gravel   S-7   COAR								-						
S-6   24-26   4   8   8   7   16   Wet, medium dense, COARSE SAND, w/gravel   S-6   24-26   4   8   8   7   16   Wet, medium dense, COARSE SAND, w/gravel   S-6   24-26   4   8   8   7   16   Wet, medium dense, COARSE SAND, w/gravel   S-6   COARSE SAND, w/gravel   S-7   COAR			and the					Location to		-				
S-6   24-26   4   8   8   7   16   Wet, medium dense, COARSE SAND, w/gravel     S-6   24-26   4   8   8   7   16   Wet, medium dense, COARSE SAND, w/gravel     S-6   CoARSE SAND, w/gravel   S-6   COARSE SAND, w/gra	S-5	19-21	5	5	4	5	8	Wet,	loose, light gr	ay, F	INE SAND			
S-6   24-26   4   8   8   7   16   Wet, medium dense, COARSE SAND, w/gravel     S-6   24-26   4   8   8   7   16   Wet, medium dense, COARSE SAND, w/gravel     S-6   CoARSE SAND, w/gravel   S-6   COARSE SAND, w/gra	-								k)					
Remarks:			140											
Remarks:													•	94
Remarks:														
Penetration Resistance (N) Guide   Cohesionless Soils (Sands, Gravels)   Cohesive Soils (Silts, Clays)   CASING SIZE:   4"	S-6	24-26	4	8	8	7	16	Wet,	medium dens	se, Co	DARSE SAN	D, w/gravel		
Penetration Resistance (N) Guide   Cohesionless Soils (Sands, Gravels)   Cohesive Soils (Silts, Clays)   CASING SIZE:   4"											1			
Penetration Resistance (N) GuideCohesionless Soils (Sands, Gravels)Cohesive Soils (Silts, Clays)CASING SIZE:4"Relative DensityPenetration ResistanceConsistencyPenetration ResistanceVery Loose0 - 4Very Soft0 - 2SPLIT SPOON SIZE:Loose4 - 10Soft2 - 4DRILL RIG TYPE:D-50Medium Dense10 - 30Medium Stiff4 - 8DRILL RIG TYPE:D-50Dense30 - 50Stiff8 - 15DRILL RIG TYPE:D-50Very DenseOver 50Very Stiff15 - 30Description of the property of th	Remark	(S:									AUG	ER SIZE:		
Relative Density         Penetration Resistance         Consistency         Penetration Resistance           Very Loose         0 - 4         Very Soft         0 - 2           Loose         4 - 10         Soft         2 - 4           Medium Dense         10 - 30         Medium Stiff         4 - 8           Dense         30 - 50         Stiff         8 - 15           Very Dense         Over 50         Very Stiff         15 - 30           Hard         Over 30         Hard	119					sistance			file.		10.5			
Very Loose         0 - 4         Very Soft         0 - 2         SPLIT SPOON SIZE:           Loose         4 - 10         Soft         2 - 4         Description         Descrip												NG SIZE:	4"	
Medium Dense         10 - 30         Medium Stiff         4 - 8         DRILL RIG TYPE:         D-50           Dense         30 - 50         Stiff         8 - 15         Stiff         15 - 30           Very Dense         Over 50         Hard         Over 30         Over 30			0	- 4	Marice		Very Soft		0 -	2		SPOON SIZ	<b>E</b> :	
Dense         30 - 50         Stiff         8 - 15           Very Dense         Over 50         Very Stiff         15 - 30           Hard         Over 30	L	oose						ff			חפוו	L RIG TYPE	D-50	
Hard Over 30	- No. 22 - 24 - 25					"		LE.	8 -	15		LINO TIFE	. D-00	
	Ver	y Dense	Ov	er 50										
N = Sum of Second and Third 6" Blow Counts  Terms Used for Second Entry of Descriptions: and = 40-50%, some = 10-40%, trace = 10% or less	N = S	um of Second and	Third 6"	Blow Co	unts	Ter	The state of the s	r Secon		9000000	and = 40-50%	some = 10-40°	%, trace = 10%	6 or less

Client Name		and the second second	West Chestnut St.						Sheet 2 of 2		Boring No.		TB-1	
STV, Inc.			on,		MA		02301	N	нв ј	OB NUMBER	R: 21061			
City/Town: Dartmouth, MA									Р	ROJE	CT NAME:	Wind	Turbines	
Location	: Behind Water [	Dept. Bu	uilding					Date & Time S	Sta	rted	Date & Tim	e Completed	Total Hours	s Worked
Groundy	vater Depth (Feet	): ~5'	Dat	e & Tim	e: 3/8	/11		3/7/11			3/8	3/11		
DRILLE	R: Todd Penticos							HELPER						
-95				Inspec	tor's Na	ame (Print)	):				Inspector's	Company:		
Sample	Depth Range	Blow	Counts	per 6 l	nches	Recovery			-		- C. (1975)			Strata
Number	(Feet)	0-6	6-12	12-18	18-24	(inches)		S		Field	Descripti	on		Changes
C 1	27.22						Nost	ad bauldara fr	0.0	n 27'	201			
C-1	27-32	-	-					ed boulders fr	On	n 27	- 32			1
		-					Rolle	erbit to 32'						
									2	ž.				
0.0	22.27	44				60"		of Bedrock 31 ite BEDROCK						
C-2	32-37	11 min				60	Gran	ILE BEDROCK	1					
		6 min												
		6 min												
4.	ii.	7 min												
C-3	37-42	6 min				59"	Gran	ite BEDROCK	<					
		7 min					-							
		6 min					1							
		7 min					1							
									B	OE 4	2'			15.
							-							
							1							
03								•						
			-											
			_											
Remar	ks: Tough to	get ca	sing de	own in	boulde	rs								
(3)											AUGE	R SIZE:		
					sistance	(N) Guid				-	104			
	hesionless Soils							oils (Silts, Clay			And the second	NG SIZE:	4"	
	ve Density Persons Per	netratio	n Resis	stance		Consistence Very Soft		Penetration 0 -	_			SPOON SIZE		
1000000	Loose		- 10			Soft		2 -			OI LI	01 0011 0122		
100	um Dense		- 30		N	ledium Sti	ff	4 -			DRIL	L RIG TYPE:	D-50	
II .	Dense		- 50			Stiff		8 -						
Ver	y Dense	Ov	er 50			Very Stiff	· · · · · · · · · · · · · · · · · · ·							
N = C	Sum of Second and	Third C"	Dlov: C-	unte	Ton	Hard ms Used fo	r Cooo	nd Entry of Descri	_		nd = 40 50%	some = 10 400/	trace = 100	6 or less
N = S	our or Second and	Third 6	DIOW CO	นกเร	Teri	ns Used 10	Secor	id chiry of Descri	ihti	10115. a	nu - 40-50%.	30111e - 10-40%	o, trace - 107	0 01 1633



# APPENDIX C

# PERMIT STATUS AND MASSACHUSETTS CLEAN ENERGY CENTER MINIMUM TECHNICAL REQUIREMENTS

## APPENDIX C

# TOWN OF DARTMOUTH REQUEST FOR PROPOSALS

## WIND ENERGY PROJECT

#### LIST OF PERMITS

#### **FEDERAL**

Agency	Permit	Activities	Status
COE Section 10	Nationwide Permit	Construction activities in navigable waters	No Navigable Waterway Impact
COE Section 404	Nationwide Permit	Discharge of dredge or fill material into US waters & wetlands.	Below Action Limits for Filling
EPA	SPCC Plan	On site storage of oil > 1,320 gallons.	Will limit Contractor to Below Action Limit
	NPDES Stormwater Construction General Permit	Discharge of stormwater from construction sites disturbing > 1 acre.	Will Comply in Construction Phase
FAA	Notice of Proposed Construction or Alteration	Construction of an object which has the potential to affect airspace (height in excess of 200' or within 20,000' of an airport).	Decision Letter 12/29/2009. Will re-submit below height limit of 417 ft (AGL).
USFWS	Migratory Bird Treaty Act Compliance	Activity with potential to harm migratory bird species	Compliant
	Endangered Species	Confirmation of no impacts to threatened and endangered species.  Act Compliance	Outside limits
FEDERAL	NEPA	Major federal action affecting the environment.	Below Threshold limits.

#### STATE OF MASSACHUSETTS

Agency	Permit	Activities	Status
EOEA	MEPA Determination: Environmental Notification Form	Alteration of more than 25 acres of land.	Below Threshold Limits
	MEPA Review: Environmental Impact Report	Alteration of more than 50 acres of land.	Below Threshold Limits
	Protected Land Regulation Compliance	Activities on protected land.	No impact on Protected Land
MDEP	Notice of Intent (NOI)	Wetland alteration.	Turbines may impact buffer zones Wetlands delineatedWaiting for Approval to File
	Noise Control Policy Compliance	Noise from wind turbine.	Report complete. Compliant. Independent Review underway.
	NPDES Individual Wastewater/Storm Water Discharge Permit	Wastewater discharge and storm water runoff during operation. This joint EPA & MDEP program.	Will comply as part of NOI

#### STATE OF MASSACHUSETTS

Agency	Permit	Activities	Status
MDEP	Massachusetts Clean Waters Act, Section 401 Water Quality Certification	Required for federal activities affecting state land.	No Federal Activities
Natural Heritage and Endangered Species Program	Notice of Intent	Wetland alteration	All work currently outside priority habitats.
	Conservation and Management Permit	Activities that could potentially affect threatened or endangered species.	Outside Limits
MDOH	General Access Permit	Alteration of state roads.	No alteration anticipated.
	Wide Load Permit	Movement of oversize project equipment.	Will Comply during Construction
MAC	Request for Airspace Review courtesy notice	Structures over 200 feet tall.	Previously submitted and approved Will resubmit relocated turbine.
CZM	Massachusetts General Law Chapter 91 (Public Waterfront Act) authorization	Structures in tidelands, ponds, certain rivers and streams.	Outside tidelands, ponds, etc.
МНС	Archeological and Historical Review	Activities that could potentially affect archeological or historical resources.	Outside Limits

#### TOWN OF DARTMOUTH

Authority	Permit	Activities	Status
Town	Zoning Board of Appeals	Special Permit Construction of Wind Turbine	Special Permit approved 1/6/2010.
	Building Permit	New construction activity in town.	Will submit during construction.
	Certificate of Occupancy	Newly constructed facility addition.	Will request after construction.
	Fire Code Approval	New development on existing facility	Will contact fire official.
	Conservation Commission	on Notice of Intent along with DEP	Will File as noted under MDEP.
	Permit for Tree Clearing		No Town ordinance.





### Minimum Technical Requirements for Community Scale Wind

All Commonwealth Wind: Community Scale Projects must demonstrate compliance with the Minimum Technical Requirements set forth in this Appendix. These requirements are not intended to be all-encompassing, nor is this Appendix intended to be a substitute for engineering specifications or for safety requirements. Site specific conditions and/or local requirements may require additional or specific technical requirements not contained in the following minimum requirements. MassCEC reserves the right to withhold payment to any projects that do not satisfy the Minimum Technical Requirements.

	Minimum Technical Requirements				
Siting Requirements	All projects seeking Feasibility or Design & Construction funding must comply with the following minimum requirements to be eligible for funding:				
	<ul> <li>All aspects of the Wind Project must comply with the local, applicable zoning by-laws, if any;</li> </ul>				
	<ul> <li>All aspects of the Wind Project must comply with the terms of the manufacturer's design and warranty requirements, if any; and</li> </ul>				
	If no bylaws are in place, the following requirements apply:				
	The area within 1.1 x the proposed turbine lay down zone (defined as the height to the tip of the blades at the highest point in the blade sweep, as measured from the proposed installation location) cannot be outside the property of the System Owner; and				
	<ul> <li>The area within 2.0 x the proposed turbine lay down zone cannot reach an existing residential property.</li> </ul>				
	If no bylaws are in place AND the requirements outlined above cannot be met, Applicants will be required to demonstrate that all affected abutters (all owners of property that is within 1.1 x the lay down zone of the turbine and all owners of residential property that is within 2.0 x the lay down zone of the turbine) are in support of the project in order to be considered eligible for funding.				
Equipment	All wind turbine models receiving funding through Commonwealth Wind must be certified as meeting IEC WT 01 standards by a third party certification agent.				
	In addition, all of the equipment and related components that comprise the Wind Project must:				
	Be new and must be designed for the specific Wind Project in question,				
	<ul> <li>Have a UL listing and must be compliant with Institute of Electrical and Electronics Engineers (IEEE) standards,</li> </ul>				
	<ul> <li>Comply with National Electric Code provisions for wind tower grounding and over-current protection, and</li> </ul>				
	Include appropriate lightning protection and surge suppression.				
Installation Requirements	The Wind Project electrical work must be performed by a Massachusetts licensed electrician professional. For more information: <a href="http://www.mass.gov/dpl/boards/el/index.htm">http://www.mass.gov/dpl/boards/el/index.htm</a>				
	The Wind Project must be installed according to the manufacturer's instructions and in compliance with all applicable codes and standards including:				





CEN	VIER				
	<ul> <li>The most up-to-date provisions of the National Electric Code (NEC) at the time of system installation, and</li> </ul>				
	Local, state, and /or federal building laws, codes and practices.				
	All systems must have an appropriate electric utility interconnection agreement in place at the time of interconnection to the utility grid. For more information:				
	http://www.masscec.com/masscec/file/InterconnectionGuidetoMA_Final(3).pdf				
	<u></u>				
	All pertinent permits and inspections must be obtained and copies kept on file as may be required by local codes and/or state law.				
	Additional general installation practices to be followed include:				
	<ul> <li>All interconnecting wires must be copper and all wiring connections must be properly made, insulated, and weather-protected,</li> </ul>				
	<ul> <li>Areas where wiring passes through ceilings, walls, or other areas of the building must be properly restored, booted, and sealed,</li> </ul>				
	<ul> <li>Thermal insulation in areas where wiring is installed to be returned to "as found or better" condition,</li> </ul>				
	<ul> <li>Warning labels must be posted on the control panels and junctions boxes indicating that the circuits are energized by an alternate power source independent of utility-provided power,</li> </ul>				
	<ul> <li>Owner's manual of operating and maintenance instructions is provided to the system owner and preferably also posted on or near the system. The owner's manual should include manufacturers specifications, serial numbers, warranty policies, etc.,</li> </ul>				
	<ul> <li>Owners are provided with, at minimum, a basic training orientation that includes maintenance instructions, troubleshooting, meter reading, and electric production reporting instructions, and</li> </ul>				
	Electrical production estimates are specific to the site and equipment.				
	The Wind Project may not be removed from the site for its useful design life as specified in the grant agreement or terms and conditions.				
Mandatory Commissioning	The Wind Project must be independently commissioned and a commissioning report must be prepared. Commissioning is the process of ensuring that the systems are designed, installed, functionally tested, and capable of being maintained and operated according to the approved design and owner's operationa needs. At a minimum the report should include: inspection process and findings, system and component testing process and findings, and initial system performance findings.				
Warranty	All equipment must have a minimum two-year full warranty to the purchaser against defects, failures, breakdowns, or excessive degradation of electrical output. The warranty shall cover the full cost, including labor, of repair or replacement of defective components or systems.				
	In addition, Applicants are <b>strongly encouraged</b> to obtain a service contract that provides the same coverage outlined above for the period after warranty.				
Meter	Each renewable energy project proposed for MassCEC funding must have a dedicated meter that:				





<ul> <li>Is readily accessible</li> </ul>	and easily	understood by	y the S	ystem Owner,
---	------------	---------------	---------	--------------

- Records only the system's AC output as measured on the AC side of the system's isolation transformer,
- Shall be separate from the utility billing meter and shall not interfere with utility billing or net-metering,
- Must be a standard utility "revenue quality" meter that conforms to applicable American National Standards Institute (ANSI) C-12 standards and shall be installed on the output side of the renewable system's isolation transformer, and
- Shall have a visible display of cumulative energy produced by the renewable energy system and be available for periodic testing and/or recalibration, if necessary.

More information about meter requirements can be found at: <a href="http://ar.masstech-pts.org/downloads/">http://ar.masstech-pts.org/downloads/</a>

#### Automated Reporting to MassCEC's Production Tracking System (PTS)

All Wind Projects must include an automated reporting system which meets the requirements described below and must report to the MassCEC Production Tracking System (PTS) for a minimum of five years.

There are three options for establishing automated reporting to the PTS:

- 1) Vendor-Supplied System: A Data Acquisition System (DAS) that has local PTS-incorporated Automated Reporting features.
- 2) Vendor-Supplied Service: A DAS with a service that offers remote monitoring that has PTS-incorporated Automated Reporting features.
- Sample Source Code Integration: A DAS vendor or service provider can customize the software of their system to incorporate this data transfer functionality.

More information about Automated Reporting requirements can be found at: <a href="http://ar.masstech-pts.org/downloads/">http://ar.masstech-pts.org/downloads/</a>