The Madaket Wind Project: The Turbine Selection Process
Presented to the Nantucket Finance Committee
17 February 2011

Presented by George H. Aronson, CommonWealth Resource Management Corporation (CRMC). Based on technical materials, information and text provided by Kevin Schulte, Sustainable Energy Developments, Inc. (SED).

These materials are intended to provide insight to the Town Finance Committee, and to other Town decision-makers and stake-holders, regarding the process of choosing a wind turbine-generator that is appropriate for the Madaket site and the Town of Nantucket. The intent is not to provide a conclusion on a specific model or size of turbine, but, rather, to outline the scope of review being undertaken on behalf of the Town. Each wind turbine in the attached matrix has been on the market for some time with a baseline track record of success in terms of fleet-wide operating availability and limited or no history of serial component failures. There are nearly 100 companies globally offering wind turbine generators with a nameplate capacity that exceeds 600 kW. The turbines in this matrix are those that have been made available to the US market and have a strong track record.

Firm pricing and offers for chosen wind turbines will be requested upon the completion of a wind resource assessment that will an analysis of extreme winds at the Madaket site. This wind data will be required to determine which IEC class turbine is suitable for the site and which manufacturers are willing to supply turbines for the site.

Basic screening criteria for manufacturers

- Basic design features
    - Horizontal axis rotor with three-blades
    - Gear-box or direct drive
- Track record with installations in the USA
    - High availability levels
    - No serial failures
- Third-party certifications
    - Design certification by an industry reviewing body
    - For new turbine models, type certification by an industry reviewing body
- Financial stability
    - Manufacturer has prior experience with specific design. Consider
        - Basis for performance for unproven model updates
        - Implementation of proven designs after changes in manufacturer or license-holder
    - Prior approval for debt financing

Process for selection of a turbine manufacturer and model

1. Identify models in proposed size range that meet basic screening criteria
2. Eliminate models with fatal flaws or otherwise not available
    - Transport constraints (on Nantucket, land transport of large blades and wide nacelles)
    - Vendor unwillingness (on Nantucket, GE and others might refuse to supply a turbine for the site due to island location or conditions, operation in high-salt environment, proximity to an operating landfill, public access to the recycling area, etc.)
3. Perform wind resource analysis to confirm key parameters
    - IEC class I vs. IEC Class II (Nantucket wind is on the edge)
    - Hub height (specified by manufacturer)
    - Net electrical output for each model on an annual basis as a function of wind resource (magnitude, direction and turbulence), turbine power curve and cut-in/cut-out speeds
4. Update pricing
5. Perform life-cycle cost analysis based on pricing and projected output, O&M costs, warranty life and terms, component replacement and prices for each revenue stream.

Status of selection process

Models identified that meet screening criteria (see attached list)
Models with potential fatal flaws or unwilling vendors being identified
Wind resource analysis in process
Format for life-cycle economic analysis in place

MW-class wind turbines

Vendor	GE	GE	Vestas	Gamesa	Pioneer / AAER	Suzlon	Fuhrlander	Nordex
Model	SE	SLE	V80	G80	P1650	S88	FL1500	N1500
MW capacity	1.5	1.5	2.0	2.0	1.65	2.1	1.5	1.5
IEC Class	IA	IIA	IA	IA	IIA	IIA	IA	IA
Hub ht (m)	80	65	80	80	80	80	80	70
Rotor diam (m)	70.5	77	80	80	77	88	70	70
Blades (ft)	112.4	123.0	128.0	128.0	123.0	141.1	111.5	111.1
Transport issue	Blade length	Blade length	Blade length	Blade length	Blade length	Blade length	Blade length	Blade length
Warranty (yrs)	2.0	2.0	2.0	2.0	2.5	2.0	2.0	2.0
Design certification	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Type certification	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes

Mid-size wind turbines

Vendor	Powerwind	EWT	Unison	Unison	Elocon	Vestas RRB	Aeronautica	Aeronautica
Model	PW56	DW52	U54	U50	T600	PS600	47-750	54-750
MW capacity	0.900	0.900	0.750	0.750	0.600	0.600	0.750	0.750
IEC Class	IIA	IIA	IIA	IA	IA	IA	IA	IIA
Hub ht (m)	59	50	60	60	60	65	65	65
Rotor dia (m)	56	51.5	54	50	48	47	47	54
Blades (ft)	88.6	81.2	85.3	78.7	75.5	73.8	73.8	85.3
Transport issue	None	Nacelle width	Nacelle width	Nacelle width	None	None	None	None
Warranty (yrs)	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Design certification	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Type certification	Pending (75+ in service)	Yes	Yes	Yes	No (20+ in service)	No (500+ in service)	No	Pending (110+ in service pre-acquisition)

Explanatory notes on data on turbines for consideration at the Madaket site

All wind turbine data provided by SED (Sustainable Energy Developments, Inc.)

All turbines listed meet basic screening criteria
EWT and Unison turbines are direct-drive; others have gearboxes

International Electro-technical Commission (IEC) Wind Turbine Class types

Wind turbine class	I	II	III	IV
Average wind-speed at hub height, m/s	10.0	8.5	7.5	6.0
Extreme 50-year gust, 3-second average wind speed, m/s	70	59.5	52.5	42
I15 characteristic turbulence (standard deviation of wind speed measured at 15 m/s)	Class A – 18% Class B -- 16%			

Higher classes designed for lower wind speeds have smaller design loads, larger blades and taller hub heights. The larger rotors can capture more wind energy and yield higher capacity factors (subject to limits on cut-in and cut-off speeds)

Design certification: obtained by manufacturers to ensure compliance with internationally approved standards and sound engineering practices.

Type certification: obtained to confirm that wind turbines of a particular type are designed, documented and manufactured in conformity with certain technical requirements to confirm capability to install, operate and maintain at sites in accordance with design assumptions.

For more information, see the NWTC site at
http://wind.nrel.gov/cert_stds/Certification/certification/index.html

Preliminary expected pricing:

Delivered to mainland location: $2.0M to $3.0M for one MW-class unit or two Mid-size units
Installed price at typical location: $5.75 M to $7.23 M
NOTE: Vendors have not confirmed willingness to supply to, or evaluate price impact on, the Madaket site due to characteristics, activities, island location, and, as applicable, the need to airlift certain turbine blades over 90 feet in length to the site

Preliminary P50 production estimates, MWh per year: -- *SUBJECT TO CHANGE PER WIND ANALYSIS*

5167 MWh/y to 7798 MWh/y for one MW-class unit
3988 MWh/y to 6268 MWh/y for two mid-size units

Preliminary estimated capital cost, $/MWh-- *SUBJECT TO CHANGE PER PROCUREMENT PROCESS*

$0.045/MWh to $0.056/MWh for one MW-class unit
$0.057/MWh to $0.076/MWh for two mid-size units