Renewable Energy Potential in Nantucket, Massachusetts

Philip H. Corcoran
SSU GPH904
Spring 2014

Nantucket Energy

- GOAL: Identify the potential for renewable energy production on Nantucket Island
- Nantucket is about 30 statute miles south of Cape Cod Massachusetts
- It is 14 miles long, 3 to 5 miles wide
- Year-round population is 10 to 12 thousand
- Summertime population is 50 to 60 thousand
- Electric power is supplied by a 35 MW cable from Harwich on Cape Cod, to a landfall near Cliffside
- No commercial electric power is produced on the island
- Preserving natural beauty is essential for maintaining the tourist-based economy

Rooftop PV Solar

- There are 14,029 buildings, houses and other structures on the island
- Total rooftop area is 178,268 square meters
- Hourly insolation data available from Nantucket airport since 1991
- PV model assumed 25% of roof space usable, 10% PV efficiency
- Total yearly solar potential is estimated at 6,040,108 kWh (20,609,706,380 BTU, 3,709 BOE)
- Enough for 803 households (at 7524 kWh yearly)

Masted Wind Turbines

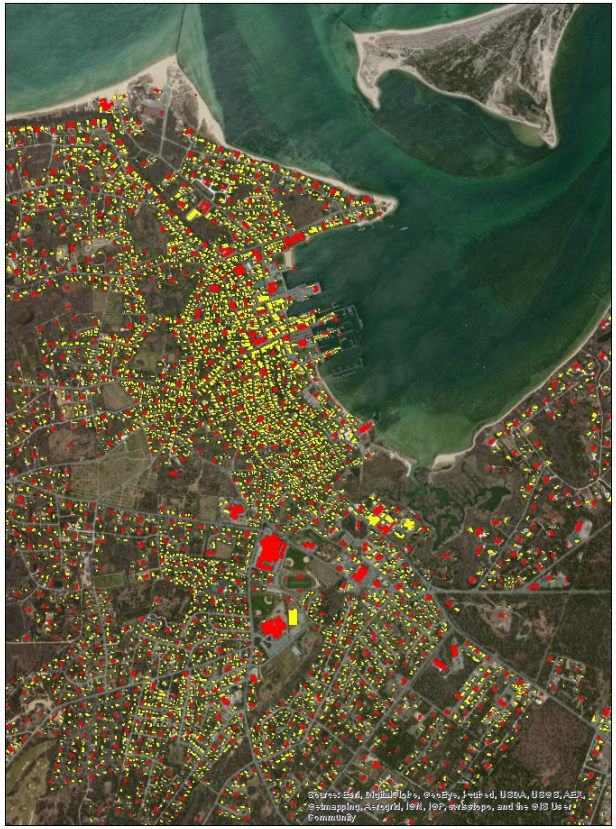
- Wind turbines mounted to structure edges or rooftop by mast (small tower)
- Bergey Excel 1kW
- Turbine diameter is 2.5 meters
- Minimum mast height is 9 meters (29.5 feet)

Site Modeling

- Siting (masted turbine installation) was modeled per structure from largest to smallest perimeter
- Turbines were spaced at least 15 meters apart
- Nantucket structures are a mean distance of 4.4 meters apart
- Skipped sites that were too close to previously-modeled turbine
- Nantucket median wind speed is 4.4 meters per second (10 MPH) at 10 meters (32.8 feet)
- Model wind speeds were calculated per site and adjusted (Hellman) for minimum mast height
- Rejected sites with wind speeds averaging near cut-in or furling speeds

Masted Turbine Results

- Red sites shown were modeled with turbines, yellow sites were not
- A total of 3,616 masted-turbine placements were modeled
- Total yearly masted wind power potential is 2,118,411 kWh (7,228,319,258 BTU, 1301 BOE)
- Enough for 281 Households



Tower Turbine

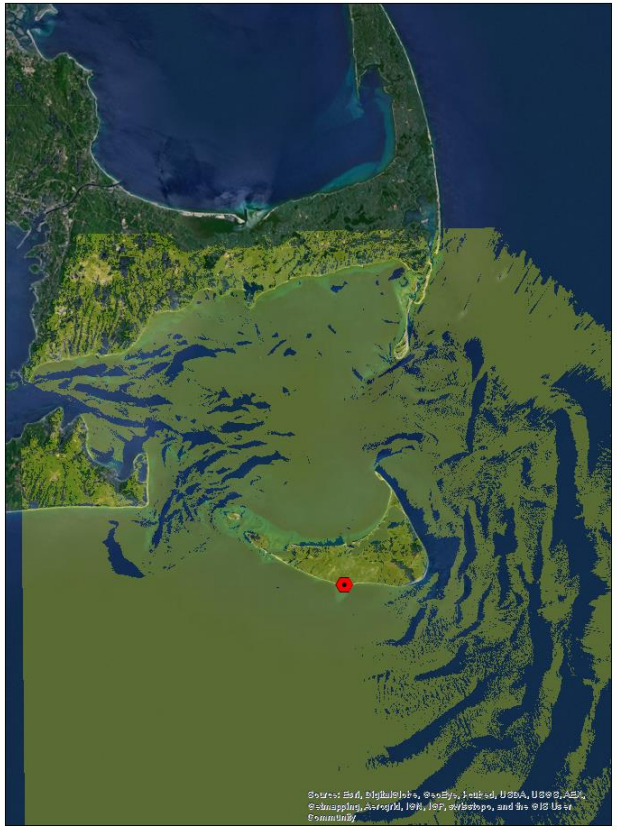
- A large number of masted wind turbines is impractical—too visible and requiring too much continual maintenance; and it produces less energy than rooftop PV solar would
- Therefore, although the wind blows all day and night, while solar radiation is only available for a few hours each day, rooftop PV solar is preferred.
- But what if we built just one large wind turbine, by the waste water treatment plant on Southshore Road?

GE 1.5 MW Wind Turbine

- Rated Capacity 1,500 kW
- Rated Speed 14 m/s
- Cut-in Speed 3.4 m/s
- Furling Speed 25 m/s
- Rotor Diameter 77 m
- Hub Height 80 m
- Tip Height 118.5 m (120 m was used for viewshed analysis)

Tower Turbine Results

- Median wind speed at the water treatment plant location is 8.9 m/s (at 80 m), which will produce 1200 kW
- Total yearly power expected is 10,512,000 kWh (35,868,432,815 BTU, 6456 BOE)
- Enough for 1397 households
- Beats out rooftop and mast power together
- However, it would be visible everywhere on the island and from far away too

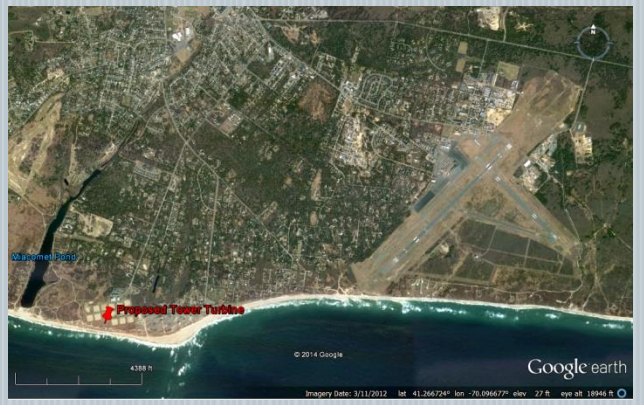


Conclusions

- Rooftop solar PV is relatively non-intrusive, but fully-utilized roofs would still only provide limited power
- Smaller wind turbines, even thousands of them, wouldn't equal the potential of solar PV.
- Large-scale wind power easily beats out individual structure installations of PV and masted turbines combined, which makes it the best choice.
- It also has the advantage of being scalable to larger turbines for greater power needs.
- It has the disadvantage of being highly visible

Further Considerations

- Relative cost information was not gathered for consideration, however it was assumed that large-scale turbine installation would be cheaper to install and maintain than individual-structure power installations
- Existing land use plans and utilities contracts were disregarded in this analysis
- Locating a 120-meter high wind turbine at the water treatment plant may place it a bit close to the airport approach path



Data Sources

- Nantucket structure and land use data files from MassGIS (http://www.mass.gov)
- Nantucket DEM from NOAA via a NASA website (http://rredc.nrel.gov/solar/old_data/nsrdb/)
- Nantucket insolation data from National Solar Radiation Database (http://rredc.nrel.gov/solar/old_data/nsrdb/)
- Electrical consumption data from the U.S. Energy Information Administration (http://www.mass.gov)
- Base map imagery from ESRI and Google Earth

Information Sources

- Bergey Excel 1 Owners Manual (http://bergey.com)
- GE Energy 1.5MW Wind Turbine, brochure GEA14954C15-MW-Broch.pdf
- EDINA Digimap Training: Wind Farms in ArcGIS
- kidwind science snack, Understanding Coefficient of Power (Cp) and Betz Limit
- HowStuffWorks "How many solar cells . . ." (http://home.howstuffworks.com/green-living/question418.htm)
- National Grid, 2011 Electric Energy Efficiency Annual Report
- Worchester Polytechnic Institute, Nantucket Baseline Energy Project 2011, Roberto Antonio, and others.