Wind Power Ithaca

An Analysis of the Ithaca Wind Resource

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Wind Power Ithaca: Table of Contents

1. Wind Resource
2. Technology
   a. Turbines
   b. Farm Layout
   c. Storage
   d. Transmission
3. Land Use
   a. Regulation
   b. Incentive
   c. Black Oak Ex.
   d. Construction Plan
4. Issues
5. Economic Analysis
6. World Scale-Up
Map of Wind Resources of the US
http://www.windpoweringamerica.gov/wind_maps.asp
New York (at the end of 2009) had an existing wind capacity of 1,274 MW.

Total electricity generation by wind power: 2,259 GwH.

1.67% of state electricity generation in 2009 from wind.

http://en.wikipedia.org/wiki/Wind_power_in_the_United_States
Zooming in on Ithaca

http://www.windpoweringamerica.gov/wind_resource_maps.asp?stateab=ny
Current Wind Technology

http://www.windpoweringamerica.gov/pdfs/20_percent_wind_2.pdf

Technical Overview

- A turbine will start producing power at speeds of 5.36 m/s and produce max output at 12.51-13.41 m/s.

- Areas in Tompkins county have average wind speeds of 6.5 m/s - but areas in Seneca County have an average wind speed of 6.5-7 m/s.

- Putting wind turbines there would be advantageous since a 10% increase in wind speed causes a 33% increase in energy output.
Farming with wind turbines

http://www.windpoweringamerica.gov/wind_resource_maps.asp?stateab=ny

- Wind turbines allow the land to be farmed and produce energy at the same time, providing tremendous economic benefit to farmers (approx $5,000-$10,000 annual lease payment per turbine).

- Wind turbines and access roads occupy less than 3% of the area on the ground of a typical wind farm (Horizon Wind Energy)

"I didn't really expect them to come all the way out here in northern Iowa to start a wind farm. But this is really great. Now we grow corn on the ground and generate power in the air—all on the same piece of property." —Delbert Watson, farmer near Clear Lake, Iowa.

http://www.horizonwind.com/about/landowners/printerfriendly.aspx
GE 1.5 MW Turbine

Tower Height: 80m
Blade Length: 41m
P = 500kw/turbine
Total Farm = 250MW/.5MW = 500 Turbines
Turbine Spacing

For 500 turbines (5 rows), need 20,000 acres (15 miles x 2 miles)

For 10 rows, need 22,000 acres (7.5 miles x 4.5 miles)

Figure 2. Illustration of Turbine Spacing (example: 3 x 10 spacing)
Farm Layout
• Compressed Air - Uses electricity to compress air (usually stored in an old mine or some other kind of geological feature). Geological have assessed salt mines around Tompkins county as possible compressed air plant sites.
Western New York has:

- Approx. 228 million cubic feet of underground storage capacity (equivalent to approx. 3 GW) across 24 depleted natural gas fields and salt caverns.

Potential CAES Sites:

<table>
<thead>
<tr>
<th>Potential Site</th>
<th>Town/County</th>
<th>CAES Capacity (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avoca Storage Cavern</td>
<td>Steuben County</td>
<td>Unknown</td>
</tr>
<tr>
<td>Morton Salt - Silver Springs Field</td>
<td>Silver Springs, Wyoming County</td>
<td>Unknown</td>
</tr>
<tr>
<td>Cargill Watkins Glen Plant</td>
<td>Watkins Glen, Schuyler County</td>
<td>Unknown</td>
</tr>
<tr>
<td>St. Lawrence Zinc Mine</td>
<td>Fowler, St. Lawrence County</td>
<td>360</td>
</tr>
<tr>
<td>Morton Salt - Himrod</td>
<td>Himrod, Yates County</td>
<td>Unknown</td>
</tr>
<tr>
<td>Cargill Deicing Technology Cayuga</td>
<td>Lansing, Tompkins County</td>
<td>Unknown</td>
</tr>
<tr>
<td>Retsof Salt Mine</td>
<td>York, Livingston County</td>
<td>Unknown</td>
</tr>
<tr>
<td>Republic Steel Iron Mines</td>
<td>Essex and Clinton County</td>
<td>Unknown</td>
</tr>
<tr>
<td>Lyon Mtn Iron Mine</td>
<td>Chateauguy, Clinton County</td>
<td>Unknown</td>
</tr>
<tr>
<td>Wingdale Quarry</td>
<td>Dover, Dutchess County</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

- Competition with natural gas storage
Mines in New York

Legend

- **Mine_type**
  - Fe
  - Ls
  - NaCl
  - NaCl ; Ls
CAES Sites

Connecting to the Grid

Electricity Transmission: National Grid owns and operates an electricity transmission system of approximately 8,600 miles spanning upstate New York.

- Low end cost estimate for materials used in line construction is $3,000 per kilometer.
Projected Grid Expansion for Wind Power

EXISTING LINES
- Existing electric power grid

PROPOSED LINES
- Wind power transmission lines in 2030
- New wind power transmission lines projected after 2030

EXISTING CAPACITY
Wind speed
At 50m (164 ft), in mph
- Superb: 19.7-24.8
- Outstanding: 17.9-19.7
- Excellent: 16.8-17.9
- Good: 15.7-16.8
- Fair: 14.3-15.7
Land Use Authorization Procedures

- Town and county governments legislate land ordinances permitting turbine installation and deciding issues such as zoning, permits, overlays, and the tax category for land. Land leases and easements are negotiated by land owners and the project sponsor.
  

- The NYS DEC State Environmental Quality Review includes: operational noise levels, bird and bat impacts; construction impacts on forests, grasslands, wetlands, sensitive ecosystems; decommission procedures
  

- For construction or alternation of structures greater than 200 ft., or within 10-20,000 ft. of an airport, Notice must be filed and approved by the FAA not to cause obstruction hazards, or adverse physical or electromagnetic interference upon navigable airspace or air navigation facilities. The FAA may require obstruction marking and lighting be installed, or the height modified.
  

- Other reviews may apply: State Historic Preservation and Park (visual/archaeological impact); Dept. of Agriculture and Markets (impact on farming operations); NYS Public Service Commission; other “interested agencies” depending on location.
  
  [The Role of Government Agencies in the Approval Process*](http://www.powernaturally.org/Programs/Wind/toolkit/16_rolegovernmentagencies.pdf)
Land Use: Deal structure and incentives

Deal Structure Patterns

• Leasing land is more common than purchasing
  • High initial outlay = low NPV
  • Existing operations continue around turbines
  • Families prefer to keep land, benefit from the lease income

Wind Energy Toolkit

• No evidence of an effect on surrounding property values

• Opposition to wind farms exists but is the minority: local stakeholders with specific issues about safety, aesthetics, property line setback distance, etc.
http://www.windaction.org/

Government Incentives

• Approved utility scale wind power systems are eligible for property tax credits:
  • Exempt from increase in taxation for 15 years due to increase in property value assessment arising from wind power installation
  • Exemption covers Municipal and School District taxes only
http://www.orps.state.ny.us/assessor/manuals/vol4/part1/section4.01/sec487.htm
http://www.orps.state.ny.us/assessor/manuals/vol4/part1/section4.01/sec487.htm

• Note: Smaller operations (< 600 kW) that meet eligibility and certification criteria benefit from additional NYSERDA cash/loan incentives and warranties
http://www.powernaturally.com/Programs/Wind/incentives.asp?i=8
Land Use Example: Enfield

“Utility Scale Wind Energy Conversion Systems”

Local Law Overview

• Law adopted by The Town Board of Enfield to establish regulations for USWECS

• USWECS use allowed by Special Permits for each area to be developed

• Environmental assessment procedures required

• Town Board sets the level of liability insurance required

Black Oak Wind Farm

• 20 250’ turbines, 30-50 megawatt/yr production; $105-120M to build

• Environmental assessment process now starting

• To include a renewable energy education and research component

• Current challenge is finding a sponsor to provide capital for the initial investment

http://www.theithacajournal.com/assets/pdf/AF942541214.PDF

http://www.ccbconstructiononline.com/enfieldenergy/questions.htm

Land Use Changes

- Direct land impacts:
  - Permanent service road
  - Turbine Pad
  - Service Center
  - Temporary construction

- Average permanent direct land impact = 0.3 ha/MW

- 79% of direct land impact from roads, 10% from turbines, 6% station, etc.

- Average temporary land impact = 0.7 ha/MW

- For 350 MW, total permanent land impact is approx = 105 ha = 260 acres of land lost.

http://www.nrel.gov/docs/fy09osti/45834.pdf
Phased Construction/Developer

- Due to the magnitude of this project, phased construction will likely be feasible.
- 5 phases, modeled after the Maple Ridge Wind Farm (75 NE of Syracuse)
  - Maple Ridge had 2 phases, but was only installed approximately 195 turbines.
- Phase 1: 140 turbines
- Phases 2-5: 90 turbines each.
- Timescale: approx 5 years.
Noise

- This turbine is rated to emit noise of 50-60 Hz but has been further insulated in order to reduce noise.

- This is similar to the noise of a low hum and is similar to the noise emitted by AC transformers.

- The noise from the blowing wind may drown out noise of turbines when farther than 1,000 feet away.

- At 1,000 feet away, environmental assessments predict that noise levels will be between 45 and 50 decibels.

- 30 decibels is as loud as a soft whisper, 40 decibels compares to the noise in a library.
Bird Impacts

• Wind turbine deaths caused by collision with wind turbines were found to be a very small fraction of anthropogenic bird deaths (National Research Council).

• Approximately 3 out of every 100,000 bird deaths (0.003%) in 2003.

• A study of bird fatalities from Maple Ridge Wind Farm (Lake Ontario) found that increases were found during migration periods.

• Compared to fatality rates of other electrical power towers, turbines are found to kill far fewer birds.

• Over time, increased technologies and techniques to steer birds away has decreased mortality.
Agricultural Lands and Transmission Line Construction

Source: http://psc.wi.gov/thelibrary/publications/electric/electric10.pdf

Pole placement on farm fields can:

• Create problems for turning field machinery and maintaining efficient fieldwork patterns

• Create opportunities for weed encroachment

• Compact soils and damage drain tiles

• Result in safety hazards due to pole and guy wire placement

• Hinder or prevent aerial activities by planes or helicopters

• Interfere with moving irrigation equipment

• Hinder future consolidation of farm fields or subdividing land for residential development

• Placement of transmission lines along field edges or between fields where windbreaks have been planted can increase erosion of soils if the windbreaks must be removed
Mitigation of Line Construction Damage

• Community partnership on design/layout

• Markers can be installed above the conductors.

• Single poles in strategic locations (fences, roads, etc.)

• Field crossings:
  • Longer spans
  • Orientation along plow pattern

• Outside crop or hay land:
  • Guy wires

• Compaction mitigation by chisel plow

• Windbreak removal
  • Selectively trimming vegetation
  • Replanting lower-growing trees and brushes beneath the line
  • Creating a new windbreak elsewhere
Economic Analysis of Ithaca Wind Power

Summary results of a thorough financial analysis which included revenues, expenses, market projections, and financing scenarios.

Historical and Projected Electricity Wholesale Prices

Weighted Average Cost of Capital – Comparable Companies Analysis
Economic Analysis of Ithaca Wind Power

Summary results of a thorough financial model which includes revenues, expenses, market projections, financing scenarios and two operating cases: a) pre-grid-tie storage solution; b) direct grid-tie (no storage)

Case 1 – NPV by Lifespan

- According to data from National Wind, the average life of wind turbines is 25 years
- NPV is clearly positive, meaning investment is profitable even considering opportunity cost (WACC)

Case 2 – NPV by Lifespan (With Storage)

- Even with cost intensive storage, the Ithaca wind farm yields a significant and positive NPV
Economic Analysis of Ithaca Wind Power

Summary results of a thorough financial model which includes revenues, expenses, market projections, financing scenarios and two operating cases: a) pre-grid-tie storage solution; b) direct grid-tie (no storage)

Case 1 – NPV to Investment Profitability Ratio

The ratio of NPV to investment indicates the number of times an investor will make back their investment within a given time period.

Case 2 – NPV to Investment Profitability Ratio (With Storage)
Economic Analysis of Ithaca Wind Power

Summary results of a thorough financial model which includes revenues, expenses, market projections, financing scenarios and two operating cases: a) pre-grid-tie storage solution; b) direct grid-tie (no storage)

Case 1 – IRR and Risk Free Rate

Case 2 – IRR and Risk Free Rate (With Storage)
Economic Analysis of Ithaca Wind Power

Summary results of a thorough financial model which includes revenues, expenses, market projections, financing scenarios and two operating cases: a) pre-grid-tie storage solution; b) direct grid-tie (no storage)

Case 1 – Break Even analysis of NPV by Electricity Price

Case 1 – Break Even analysis of NPV by Electricity Price (With Storage)
Global Scale-Up


- Current Production = 160 GW
- Electrical Energy Consumption = 1.7 TW
- Need to Make-Up = 1.54 TW
- Viable Capacity = 72 TW

![15km Global Wind Map at 80m](http://news.cnet.com/i/bto/20080304/3t_global_wind_540x420.jpg)
Global Scale-Up Cont.- Layout

http://geology.com/articles/night-satellite/satellite-view-of-earth-at-night-750.jpg;

- Average Coastal Wind Speed = 10 m/s
- # of Turbines Required = 1,100,000
- Coastal Area Needed (3 rows) = 56,000 miles long; 1 mile wide
- Total World Coastline = 220,000 miles (25.5% of total or equal to the coastline of the US and EU)
Global Scale-Up Cont.- Materials

- # of Turbines Required = 1,100,000

<table>
<thead>
<tr>
<th>Material</th>
<th>MM Tons/Total Farm</th>
<th>% of World Consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel</td>
<td>146.8</td>
<td>11</td>
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<tr>
<td>Aluminum</td>
<td>2.5</td>
<td>4</td>
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<tr>
<td>Copper</td>
<td>8.7</td>
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<tr>
<td>Concrete</td>
<td>1.6</td>
<td>0.1</td>
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<tr>
<td>Fiberglass</td>
<td>20.2</td>
<td>470</td>
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Questions and Comments?
Additional References

- http://www.windpoweringamerica.gov/wind_maps.asp
- http://en.wikipedia.org/wiki/Wind_power_in_the_United_States
- http://www.windpoweringamerica.gov/pdfs/20_percent_wind_2.pdf
- www.ithaca.edu/faculty/.../Renewable_Energy_Wind_Lecture.ppt
### Other Turbine Technical Data

**Technical data**

<table>
<thead>
<tr>
<th>Operating Data</th>
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<th>1.5xle</th>
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<tbody>
<tr>
<td>Rated Capacity:</td>
<td>1,500 kW</td>
<td>1,500 kW</td>
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<tr>
<td>Temperature Range:</td>
<td>-30°C – +40°C</td>
<td>-30°C – +40°C</td>
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<tr>
<td>(with Cold Weather Extreme Package)</td>
<td>-40°C – +50°C</td>
<td>-40°C – +50°C</td>
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<td>Operation Survival:</td>
<td></td>
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<tr>
<td>Cut-in Wind Speed:</td>
<td>3.5 m/s</td>
<td>3.5 m/s</td>
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<tr>
<td>Cut-out Wind Speed (10 min avg.):</td>
<td>25 m/s</td>
<td>20 m/s</td>
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<td>Rated Wind Speed:</td>
<td>14 m/s</td>
<td>11.5 m/s</td>
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<tr>
<td>Wind Class — IEC:</td>
<td>IIa ($V_{e50} = 55$ m/s $V_{ave} = 8.5$ m/s)</td>
<td>IIIb $V_{e50} = 52.5$ m/s $V_{ave} = 8.0$ m/s</td>
</tr>
</tbody>
</table>

**Electrical Interface**

- Frequency: 50/60 Hz
- Voltage: 690V

**Rotor**

- Rotor Diameter: 77 m
- Swept Area: 4657 m²

**Tower**

- Hub Heights: 65/80 m
- Power Control: Active Blade Pitch Control

**Power Control**

- Active Blade Pitch Control
#12 According to the Energy Information Administration (EIA) Western New York has approx. 228 million cubic feet of underground storage capacity (equivalent to approx. 3 GW) across 24 depleted natural gas fields and salt caverns.

A Compressed Air Energy Storage Engineering and Economic Study performed in 2009 identified these sites as possible CAES sites; however, an extended review of these sites indicates that these sites may also be desirable for natural gas storage. Further study is required to assess the suitability of these sites for CAES.

In order to be considered viable CAES facilities need at least three basic elements. First, these facilities need a confined space (such as a salt cavern) that can securely store a sufficient volume of compressed air. Second, the location must have access to natural gas transmission in order to power the turbine. Finally, the site must have access to electric transmission so that the power generated can be delivered to the grid.

#22 [www.ithaca.edu/faculty/](http://www.ithaca.edu/faculty/).../Renewable_Energy_Wind_Lecture.ppt


#25

- Work with agricultural landowners to determine optimal pole heights, pole locations
- In areas where aerial spraying and seeding are used, pole height can be minimized and markers can be installed above the conductors.
- Use single-pole structures and placing the line along fence lines or adjacent to roads
- If crossing a field, larger longer spans structures can be used. If the structure is not single-pole, it can be oriented with the plowing pattern.
- Guy wires can be kept outside crop or hay land and have highly visible shield guards.
- If compaction has occurred, affected soils can be chisel plowed over as needed to break up compacted layers.

Trimming the windbreak vegetation selectively, replanting lower-growing trees and brushes beneath the line, or creating a new windbreak elsewhere can lessen the effects of windbreak removal.

#26 Assumed a 0.045 current wholesale price of electricity based solely on conversation with Cathles et. al on November 29th, 2010. Projections using historical growth rate calculated in financial model