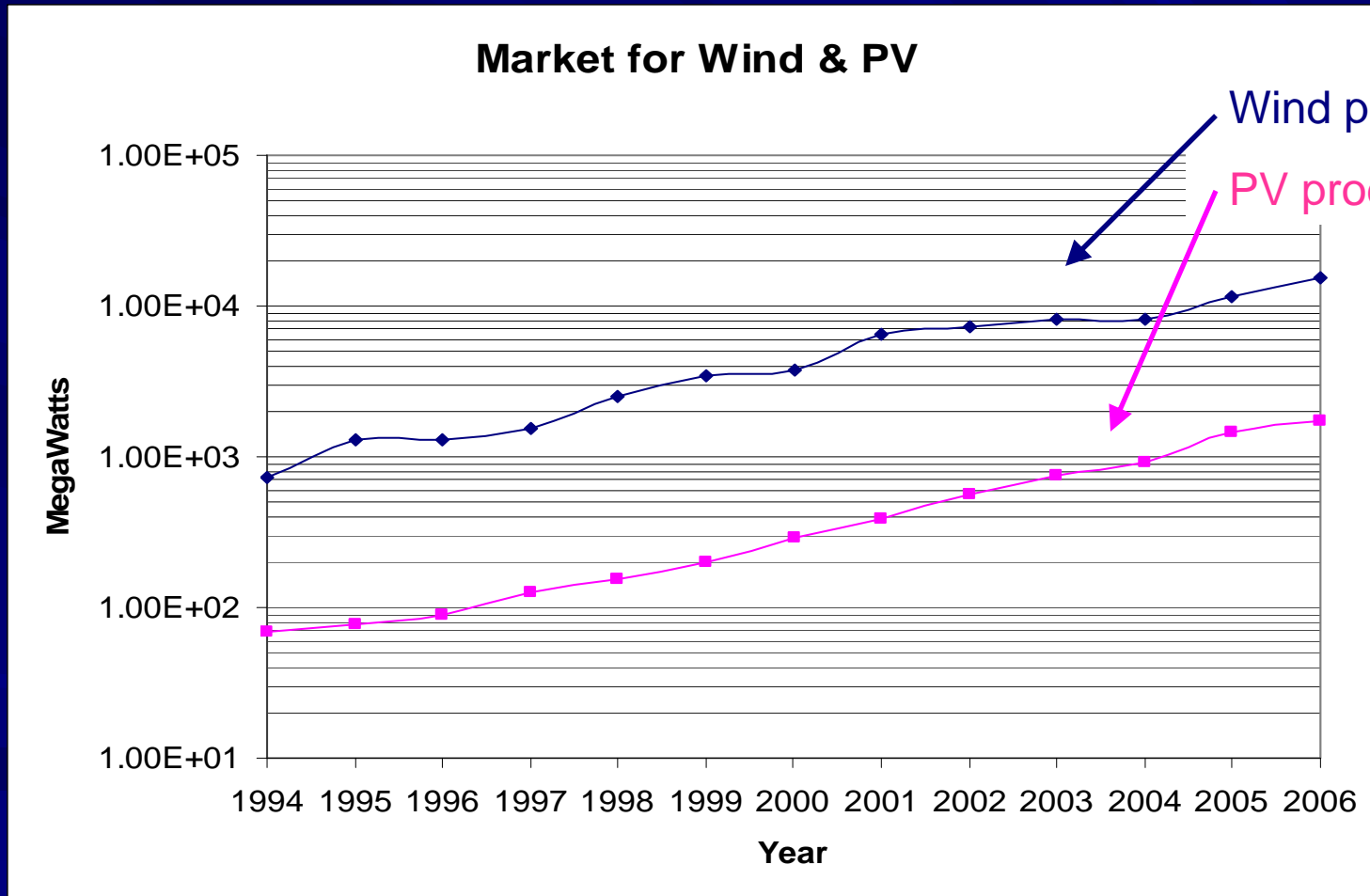


Wind Power in the Garden State

Presented by: Dr. Peter Mark Jansson, PP PE
Associate Professor – Electrical & Computer Engineering
College of Engineering, Rowan University

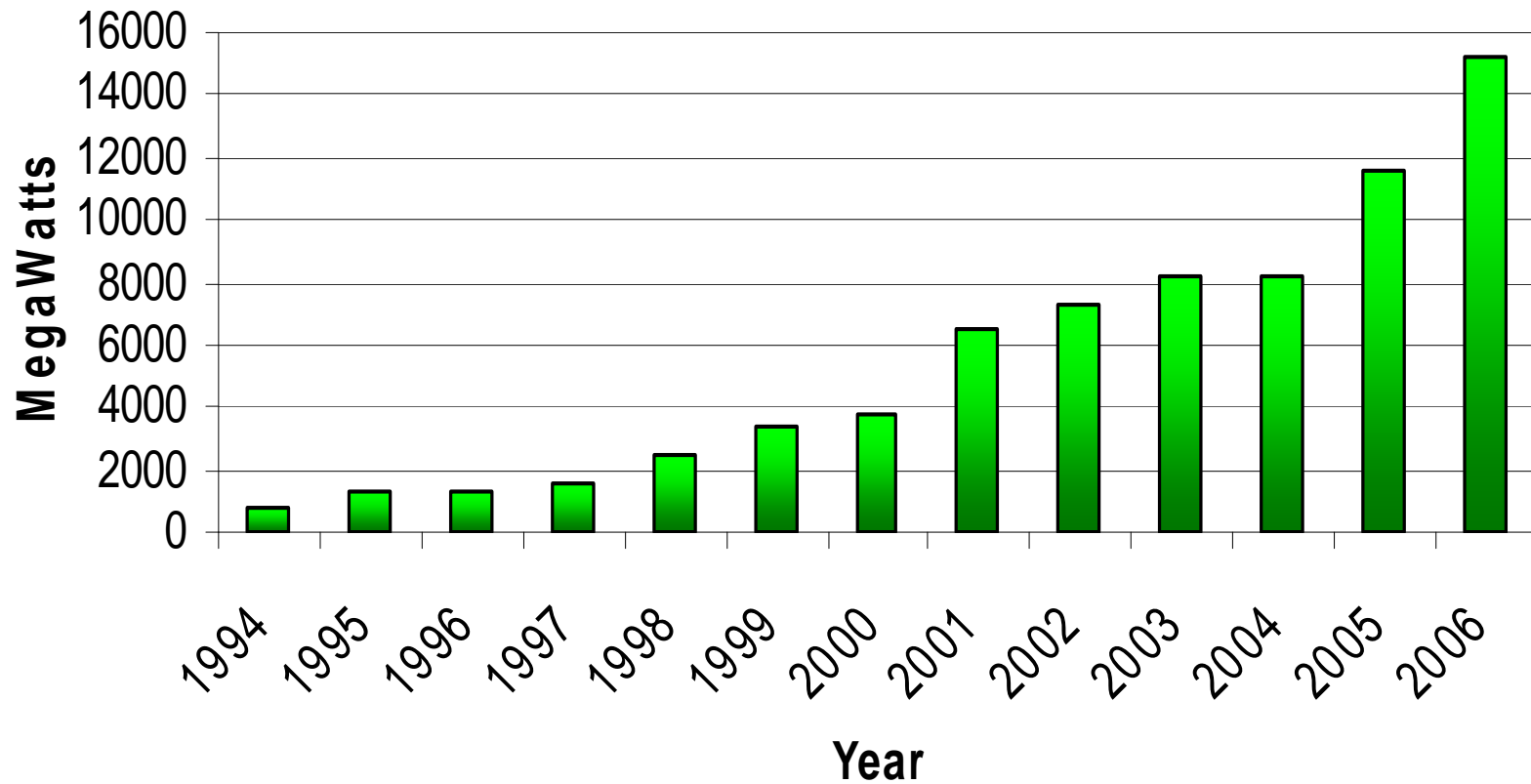
ENERGY FUTURES FORUM
2008 New Jersey Association of Energy Engineers
PSEG Conference Center, 80 Park Plaza, Newark NJ
23 April 2008

Global Wind & PV Markets (1994 -2006)



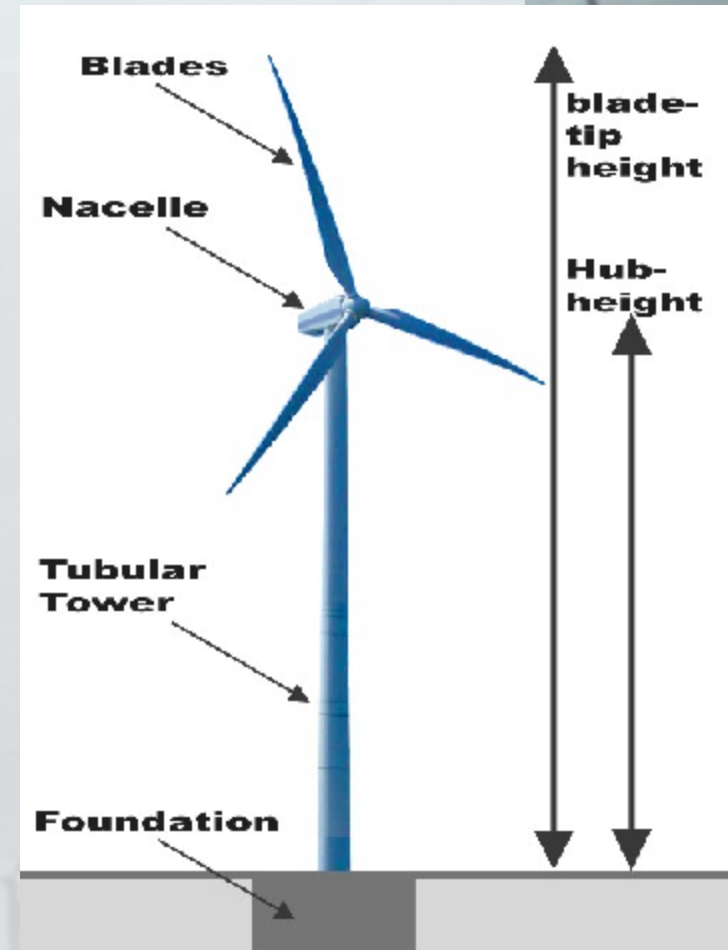
Wind Market

Annual Installed Wind Capacity



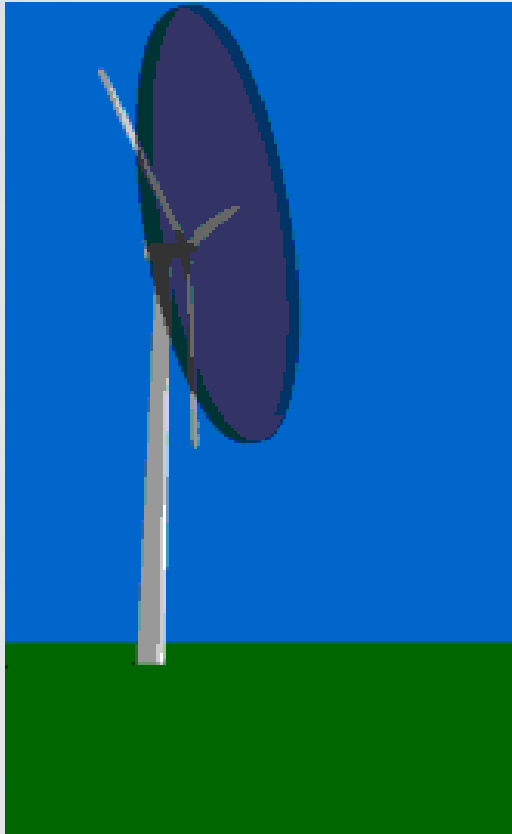
Wind Energy Basics

- Wind is a form of solar energy
- Caused by uneven heating of the atmosphere by the sun, irregularities of the earth's surface, and rotation of the earth
- Wind flow patterns are modified by the earth's terrain, bodies of water, and vegetation



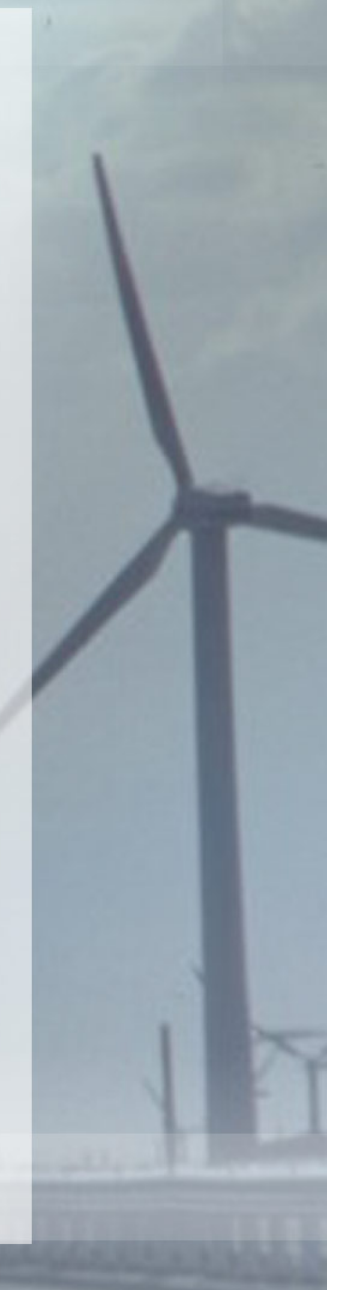
Wind Turbines

- A wind turbine obtains its power input by converting the force of the wind into a torque acting on the rotor blades.



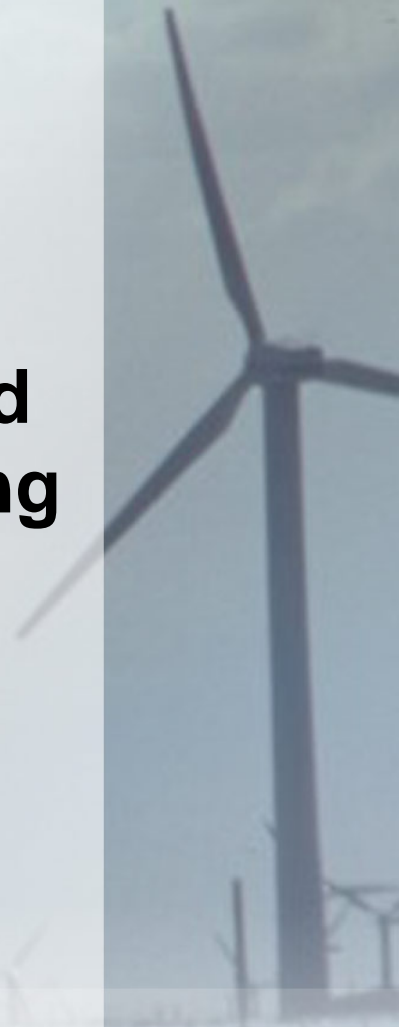
© 1998 www.WINDPOWER.org

The amount of energy which the wind transfers to the rotor depends on the density of the air, the rotor area, and the wind speed.



Advantages of Wind Power

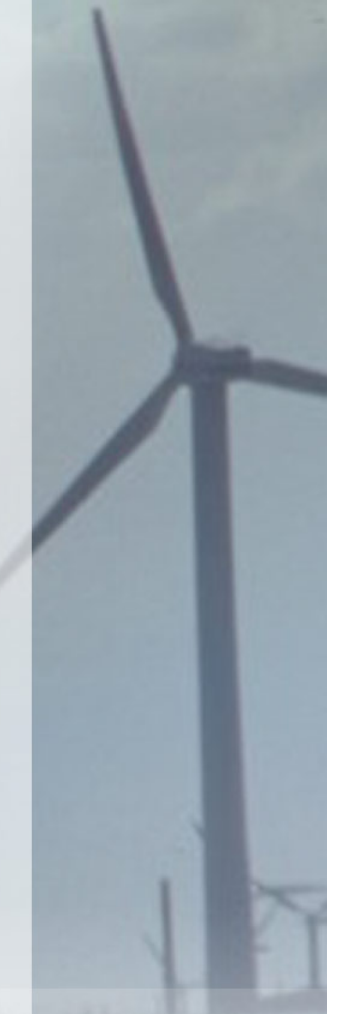
- **One of the lower priced renewable technologies:**
 - Large machines around 5-8 cents/kWh
 - Smaller machines around 9-12 cents/kWh
 - in good wind regimes ($>5.5\text{m/s}$ @ 30m)
- **Requires very little land use, land around turbine tower can still be used for farming**
- **Turbines are available in many possible sizes**
- **Wind turbines are good neighbors**
 - Quiet, sleek design, aesthetic, minimal negative impact on wildlife



Siting Considerations

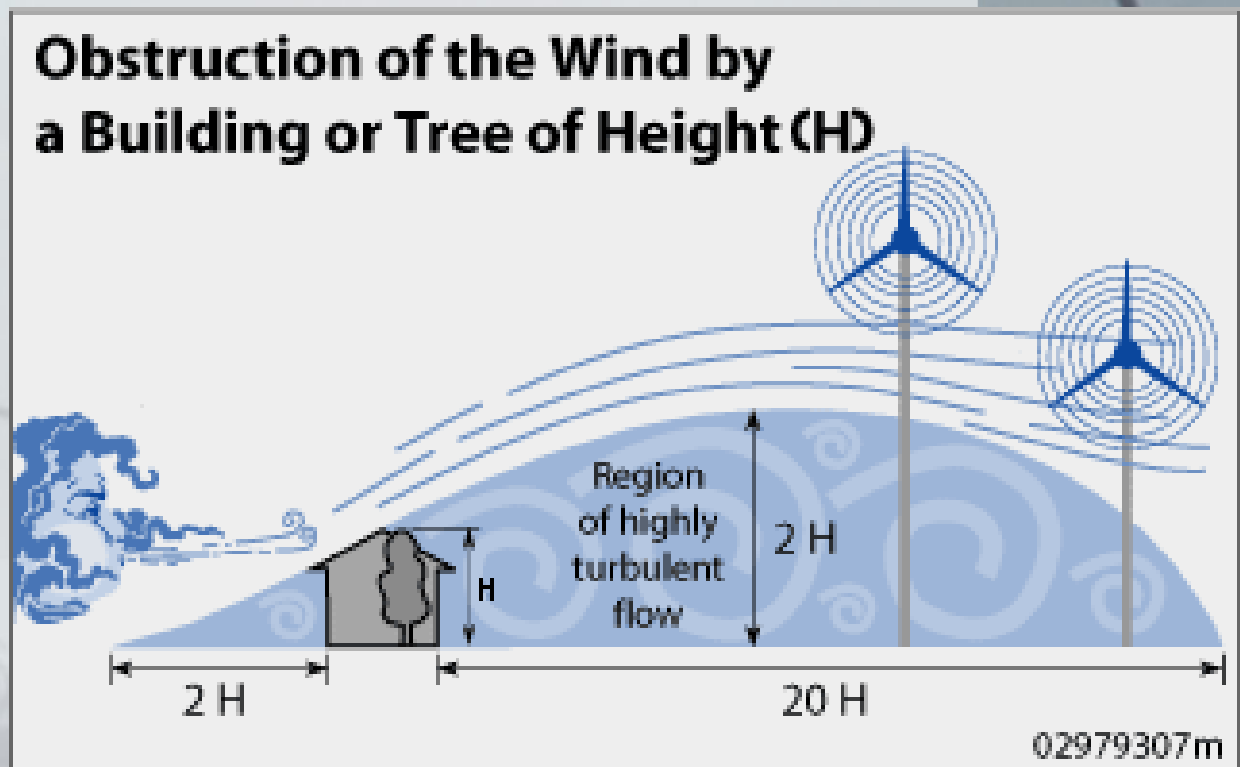
Factors to consider:

- Low density of local residents (min 1 –2 acre lot size)
 - Minimal viewshed concerns
 - Adequate set-backs from property lines, structures, roads, power lines, etc.
 - Zoning restrictions
 - Distance to closest interconnection point
- MOST IMPORTANT**
- Good wind resource (> 5.5 m/s)



Siting Considerations (cont.)

- Factors to consider:
 - Surrounding terrain, including buildings, trees and topography
 - Prevailing wind directions
 - Tower height



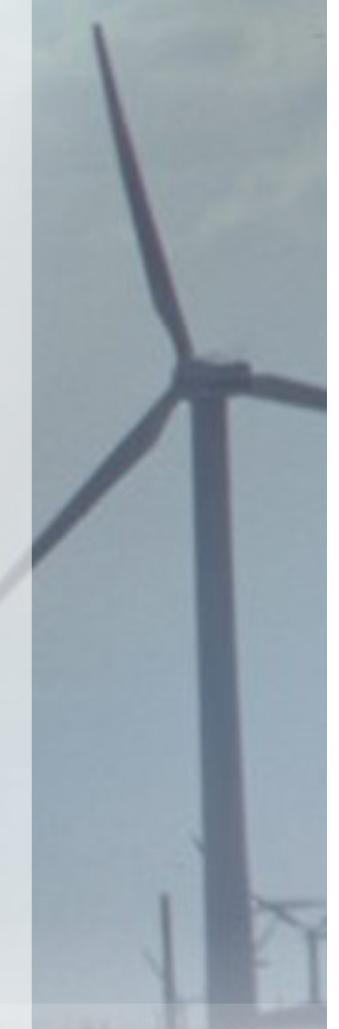
Permitting



- **Local and State (CAFRA, NJDEP, etc.) level, each local jurisdiction is unique:**
 - **NJWWG encouraging adoption of Model Wind Ordinance to accelerate adoption of wind by municipalities**
- **Permitting can be complicated and can take time**

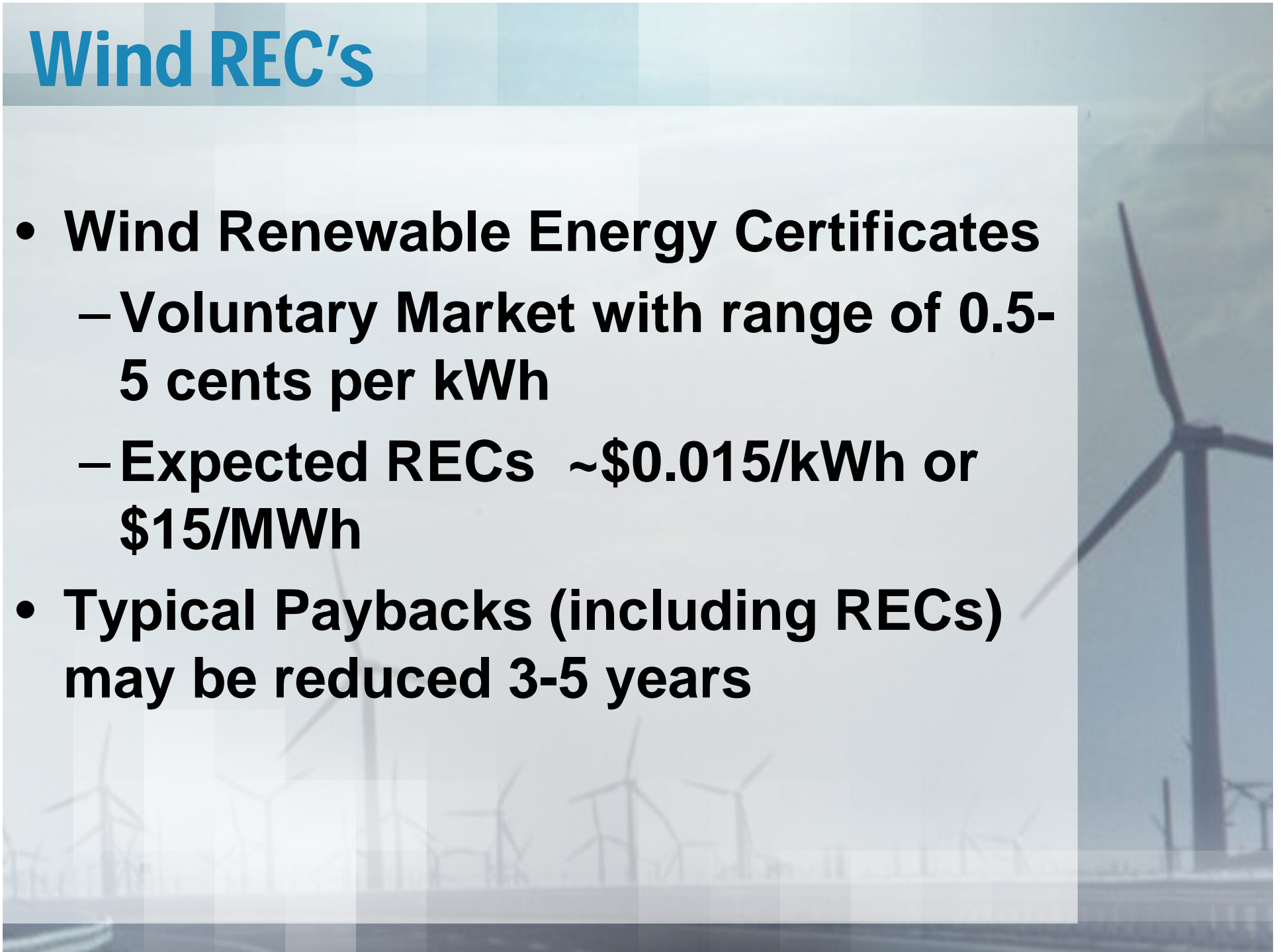
Economics

- **Turbine costs**
 - \$6,000 for a 1 kW machine
 - \$34,000 for a 10 kW machine
 - ~\$2,000 per kW on medium sized turbines
 - ~\$1,000 per kW on large turbines
- **Installation costs**
 - typically 30-50% of turbine costs for > 10kW machines, higher % for smaller machines
- **Maintenance costs**
 - about 1 – 3% of initial installed cost per year
- **Paybacks***
 - typically over 20 years for 10 kW turbines at a 5.5 m/s site with no incentives
 - typically about 10 years for 50 kW turbines at 5.5 m/s sites with no incentives
- * Based on electric rates of 14 cents/kWh



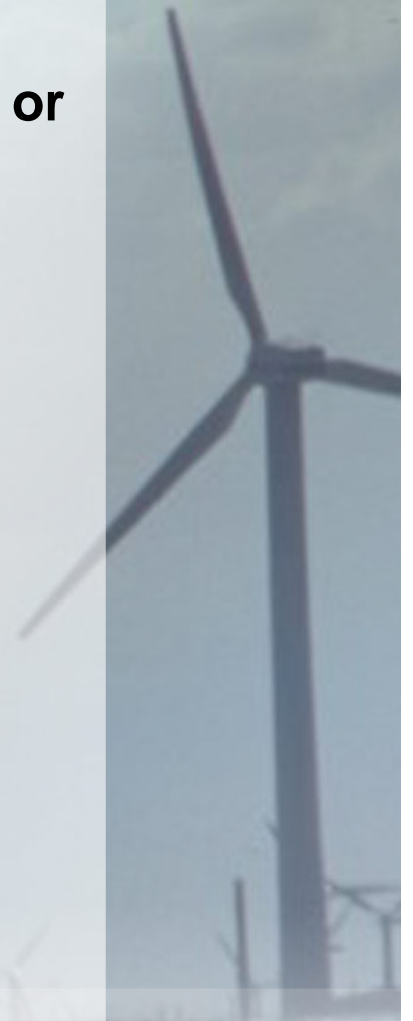
Wind REC's

- **Wind Renewable Energy Certificates**
 - Voluntary Market with range of 0.5-5 cents per kWh
 - Expected RECs ~\$0.015/kWh or \$15/MWh
- **Typical Paybacks (including RECs) may be reduced 3-5 years**



Typical Wind Turbine Sizing

- **Large Scale Wind Turbines**
 - Over 600kW
 - Towers usually over 60 m
 - Electricity typically sold to group who owns property or utility
- **Medium Scale Wind Turbines**
 - Usually under 250kW
 - Towers usually 45 m or less
 - Designed to off-set customer's purchases of utility electricity
- **Small Scale Wind Turbines**
 - Usually under 100kW
 - Designed to off-set customer's purchases of utility electricity
 - Adaptable to multiple applications
 - Distributed generation
 - Agricultural, residential, commercial, municipal
 - 30 to 40 meter towers typical for 10 kW turbines
 - Towers can be free-standing or have guy wires



Turbine Specifications

- **Bergey Excel**
- **Rated Power:
10 kW**
- **Rotor Diameter:
7 m**
- **Hub Height:
18/24/30/36 m**
- **Cut-In Wind Speed:
3.5 m/s**
- **Rated Wind Speed:
14 m/s**



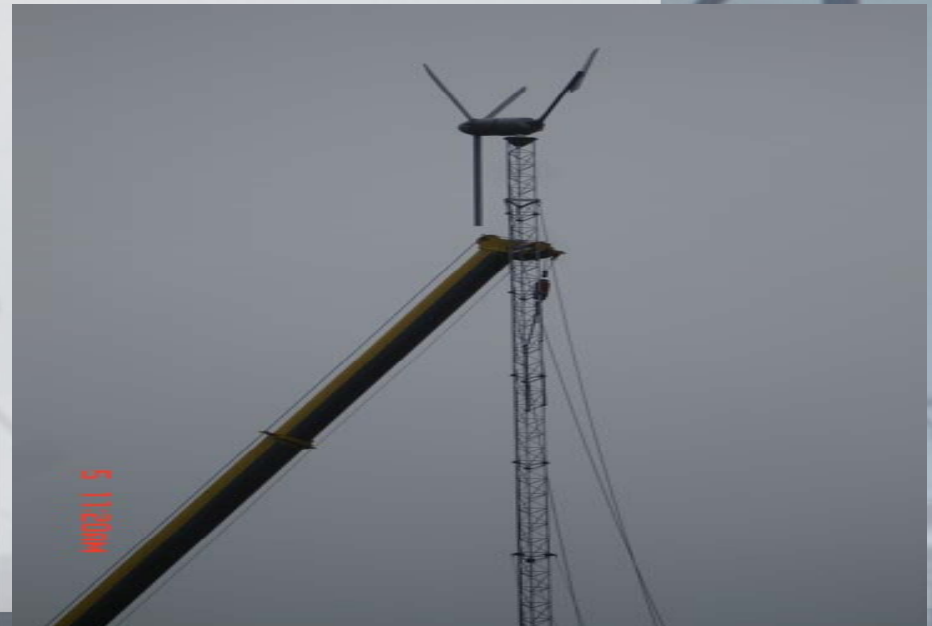
Tower/Turbine Assembly

PHOTOS COURTESY OF ALTERNATIVE ENERGY ASSOCIATES



Tower Lift

PHOTOS COURTESY OF ALTERNATIVE ENERGY ASSOCIATES



Cable Tensioning

PHOTOS COURTESY OF ALTERNATIVE ENERGY ASSOCIATES





Turbine Specifications

- **Jacobs Model 31-20**
- **Rated Power:
20 kW**
- **Rotor Diameter :
9.5 m**
- **Hub Height:
24/30/36 m**
- **Cut-In Wind Speed:
3.5 m/s**
- **Rated Wind Speed:
12 m/s**



Turbine Specifications

- **Fuhrlander FL 100**
- **Rated Power:
100 kW**
- **Rotor Diameter :
21 m**
- **Hub Height:
35 m**
- **Cut-In Wind Speed:
2.5 m/s**
- **Rated Wind Speed:
13 m/s**

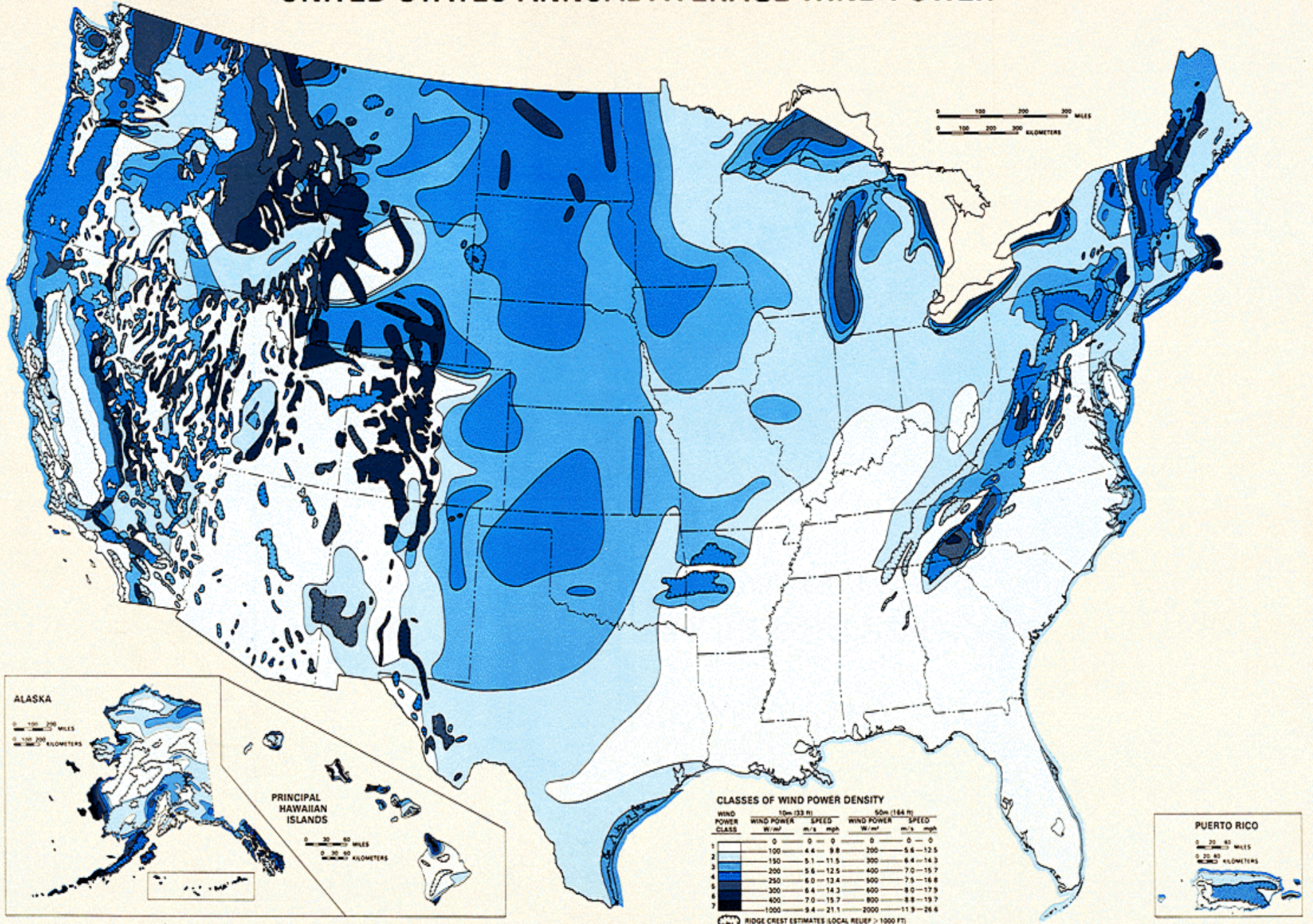


First Step: What is Your Wind Resource?

- **Consult Available Wind Maps**
- **Use Web-based Estimators**
- **Consult Your Wind Energy Provider**
- **Are you in a Fair - Good Area?**
 - with $> 5 - 5.5$ m/s annual average wind
 - Measured at 30 m height?
- **Checkout Website of NJ Wind Energy Explorer**
 - <http://www.windexplorer.com/NewJersey/NewJersey.htm>



UNITED STATES ANNUAL AVERAGE WIND POWER



Wind Resource Projection

- **NREL Wind Map:**

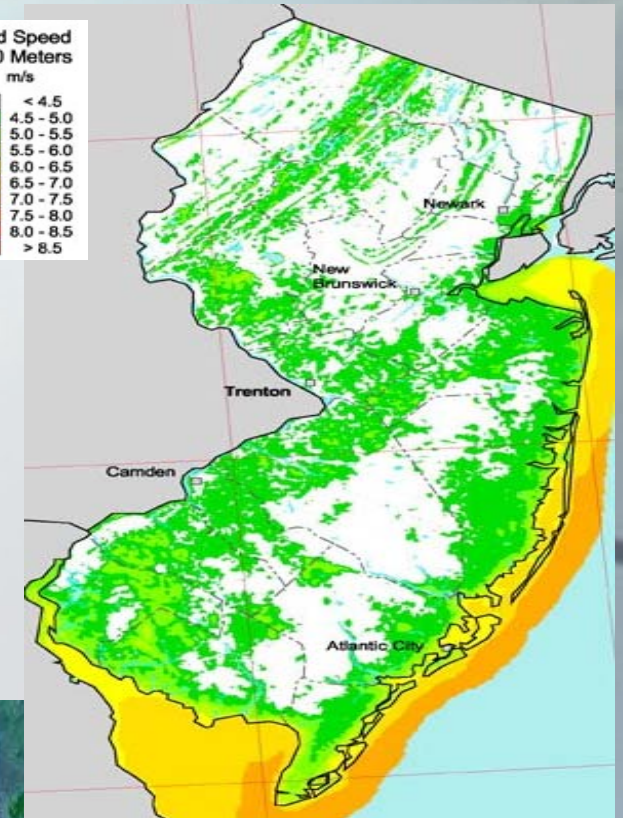
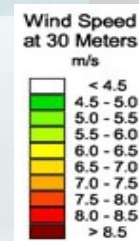
- Wind speed maps
- (http://www.eere.energy.gov/windandhydro/windpoweringamerica/images/windmaps/nj_30m_800.jpg)

- **AWS Truewind Map:**

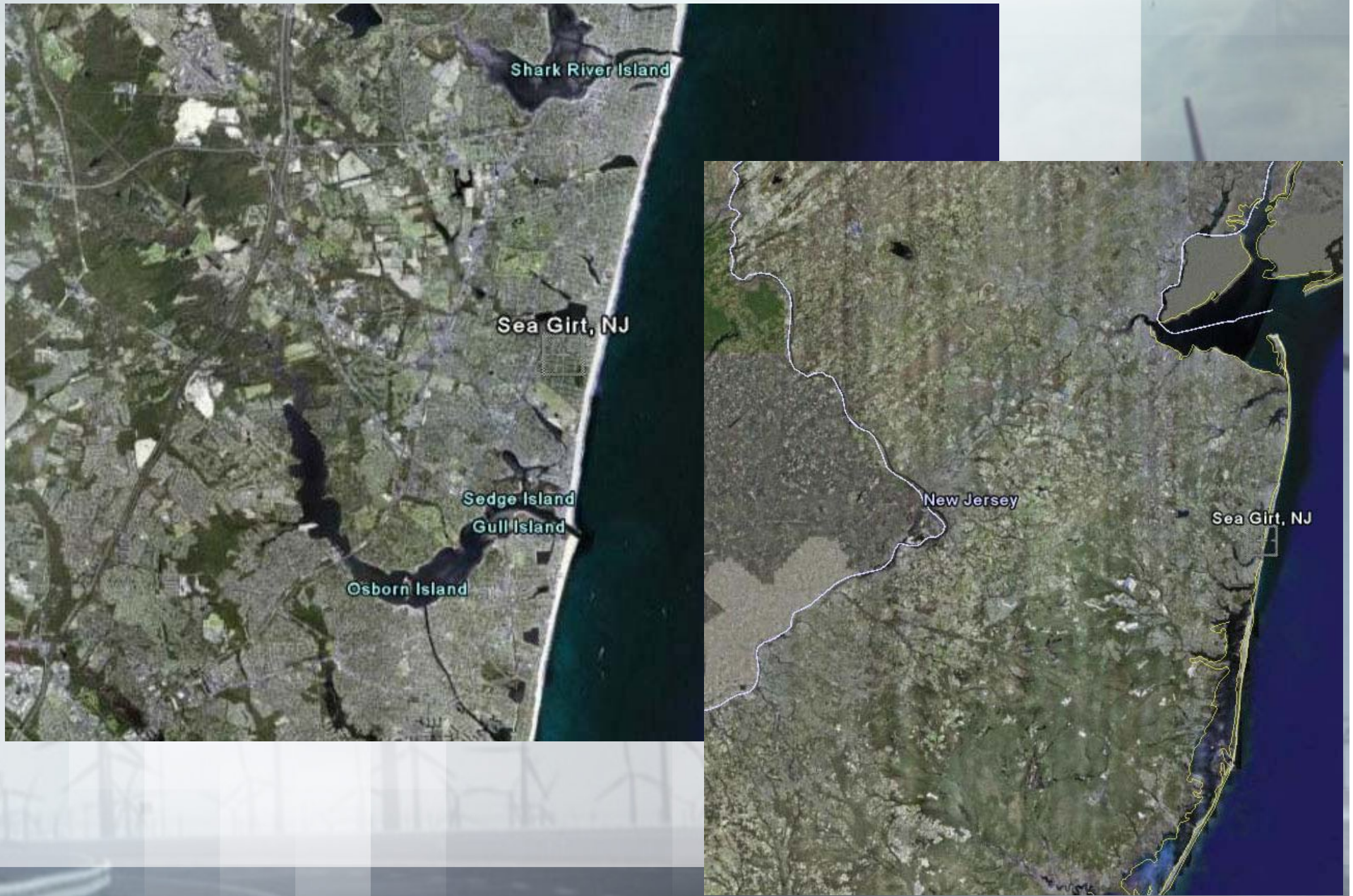
- High resolution wind maps
- (<http://www.awstruewind.com/maps/united-states.cfm/region/46688>)

- **Firstlook Wind Projection:**

- Automated coordinate wind mapping (<http://firstlook.3tiergroup.com/>)

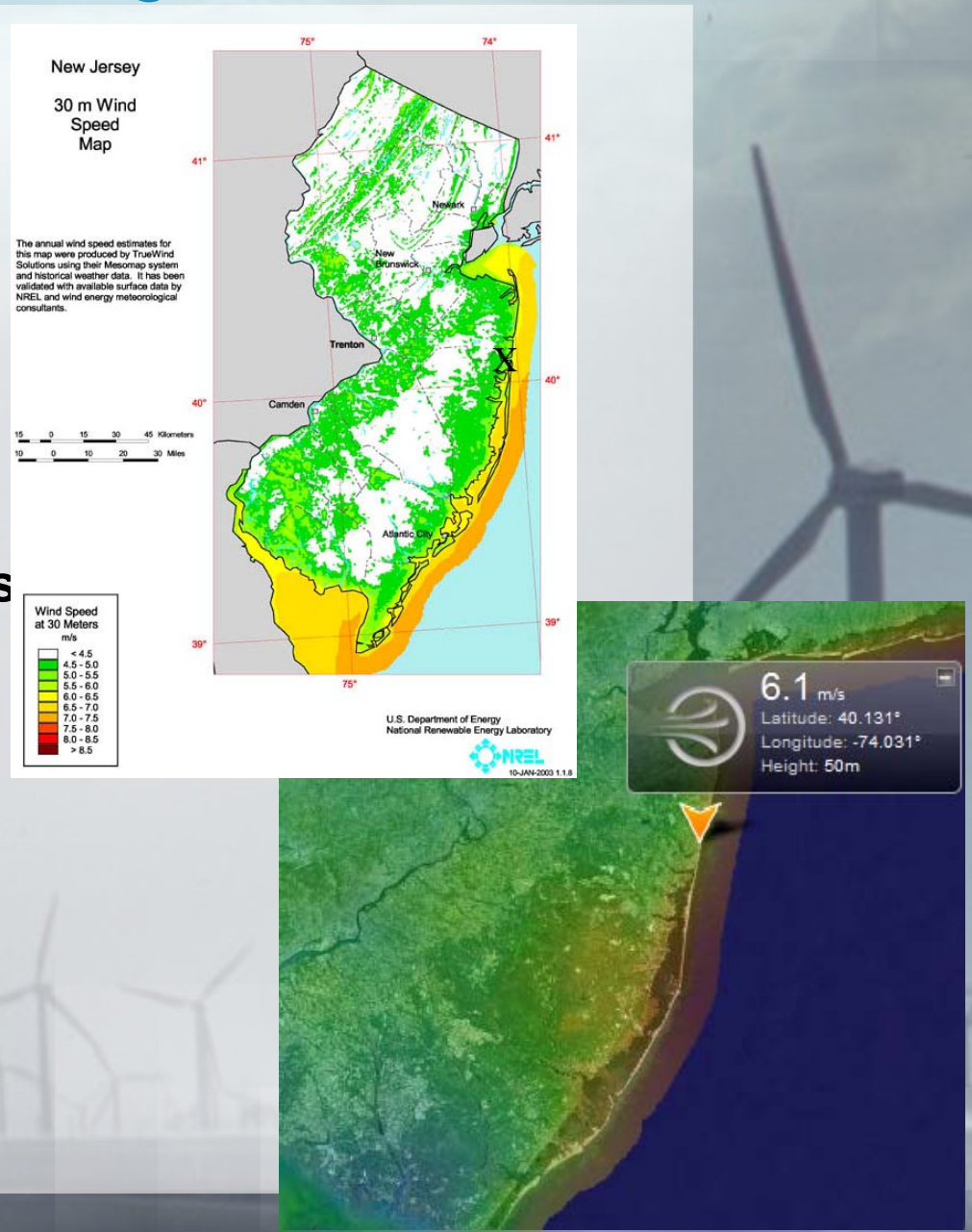


Sea Girt Project Example



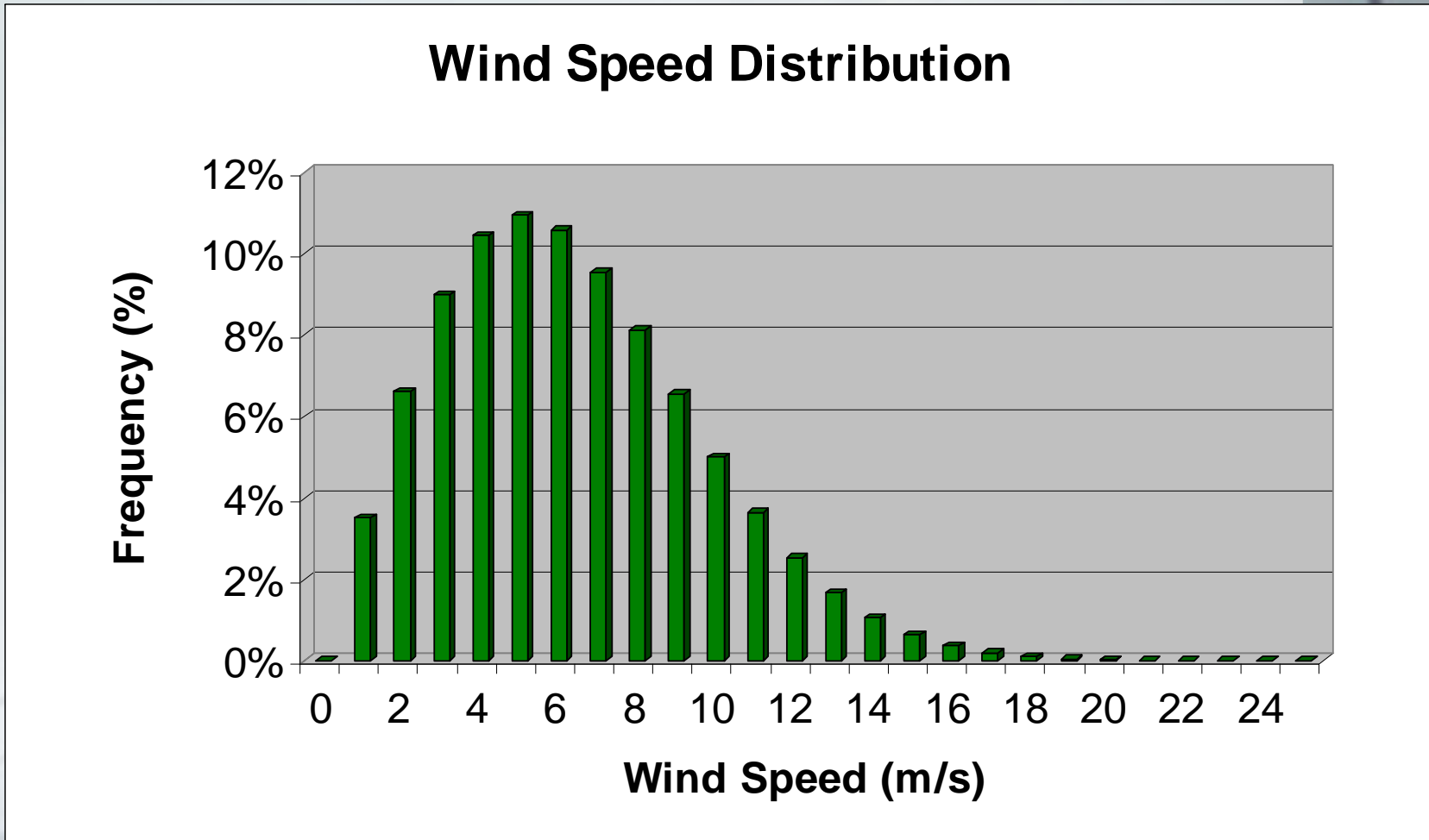
Sea Girt Resource Projection

- **NREL Wind Map:**
 - Mean Wind Speed of 5.3 m/s at 30 m
- **Firstlook Wind Projection:**
 - Mean Wind Speed of 6.1 m/s at 50 m
- **NJ Wind Energy Explorer:**
 - Mean Wind Speed of 6.34 m/s at 70 m
- **Projected Wind Speed at 50 m:**
 - Used:
 - 6.05 m/s



Sea Girt Resource Projection (cont.)

- Projected 6.05 m/s at 50 m with wind shear value of 0.24, Results in Wind Distribution Graph Shown Below



Sea Girt Sample Project



- **Fuhrlander FL250**
- **250 kW turbine at 42 m**

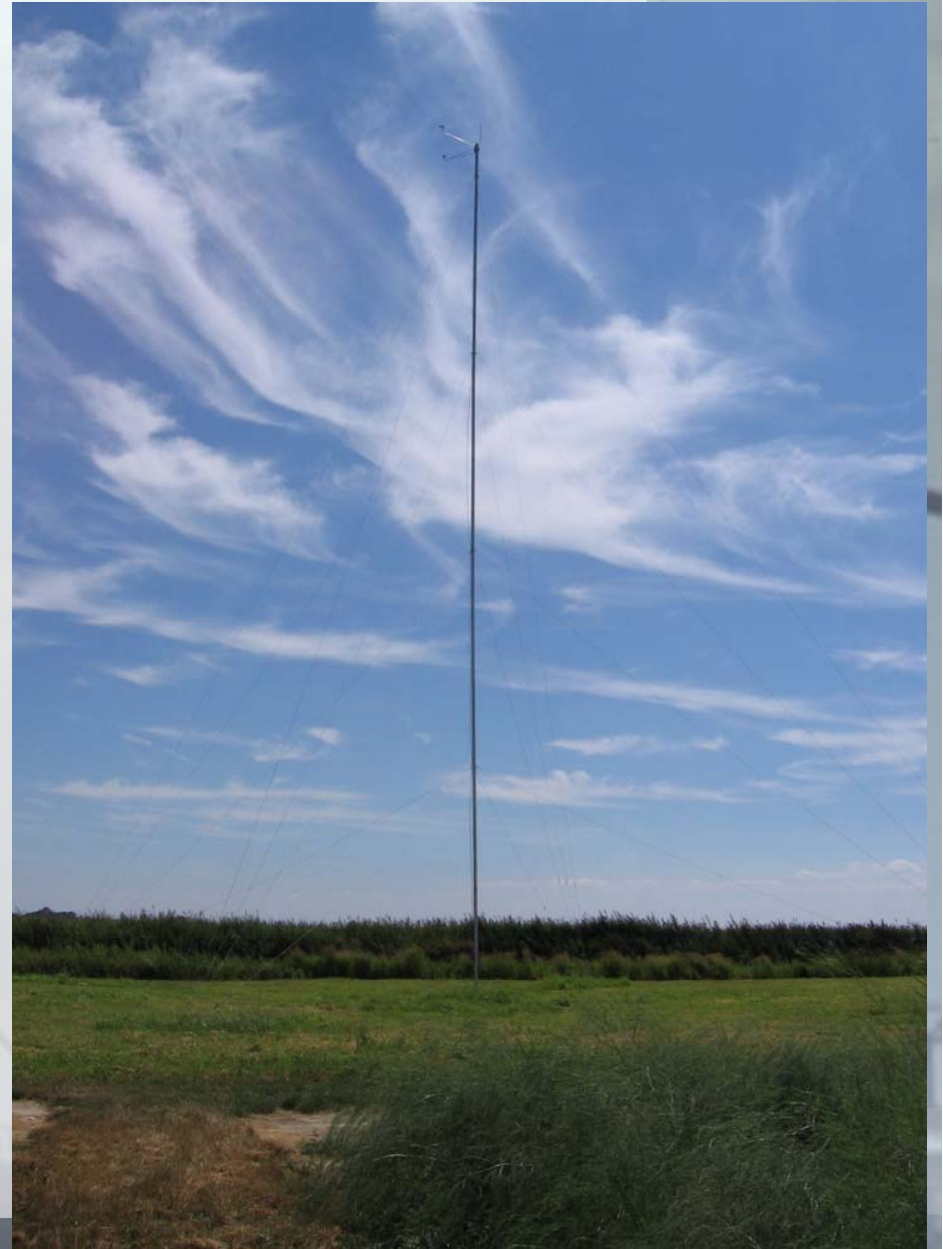
- **Operating Time: 88.13%**
- **Capacity Factor: 19.55%**
- **Annual Net Production: 398,854 kWh**

- **Gamesa G87**
- **2000 kW turbine at 78 m**

- **Operating Time: 91.02%**
- **Capacity Factor: 31.88%**
- **Annual Net Production: 5,202,424 kWh**

Anemometer Data Collection

- **Temporary mast (30-50m) constructed in order to measure wind speed and direction at specific site**
- **Minimum data collection period of one year optimal for multi-year projections**
- **Data used to complete a much more accurate assessment of site viability over life of wind system**
- **NJ Anemometer Loan Program website:**
 - <http://www.rowan.edu/cleanenergy>



The Future of NJ Wind

WIND RESOURCES:

NJ wind ranges from marginal to fair/good to excellent resources as you move from: mainland to coastal to offshore locations
Wind resources also improve with Height

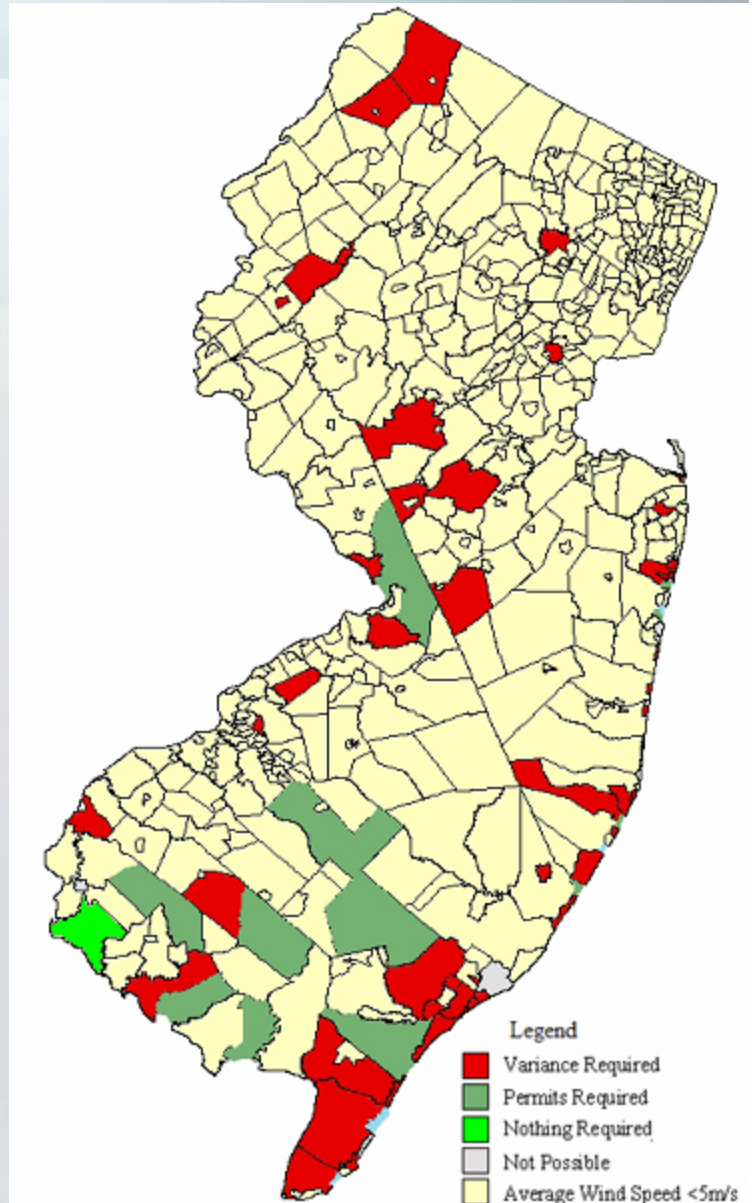
PUBLIC POLICY CONSTRAINTS:

NIMBY

Most municipalities require variance

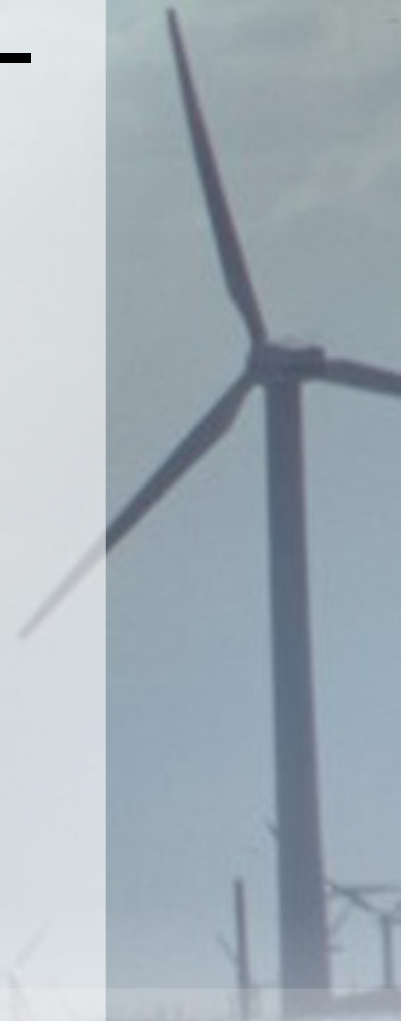
FINANCIAL CONSTRAINTS:

Voluntary REC market is insufficient (order of magnitude below SREC)
Performance based incentives will help



In NJ By 2020

- **Nonetheless, if we remove barriers**
- **Our NJ Wind Future may be bright –**
- **Onshore – small to medium**
 - MWs to 10's of MWs
- **Onshore – large**
 - 10's of MWs
- **Offshore – large**
 - 100's of MWs
- **Germany @ 24GW – NJ may attain 1.2 GW**



New Jersey's First Wind Farm – 7.5MW

