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Charting a Course to Energy Independence

Providence, RI
August 9-12, 2009

Renewable Energy Track Session I: Wind Advisory
The Latest in Wind to Energy Systems

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Getting Started With Wind

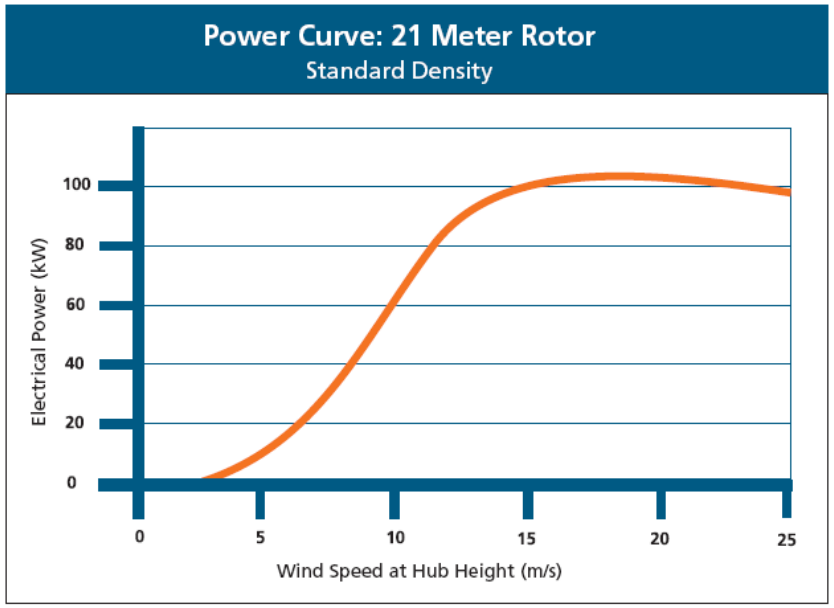
- Wind resource assessment
  - Understanding your resource
- Economics
  - Available turbine technologies
  - Is your project viable
- Community impact
  - People & wildlife: visual, noise, ice throw

Initial Site Assessment

- Project location is a critical factor
  - Wind
    - How much power can be produced
  - Interconnection
    - Offset existing load, or sell power wholesale
  - Constraints
    - Project size, turbine height, neighbors, environment

Why Windspeed Matters

- Power = ½ (air density)(swept area)(wind velocity)^3
- Turbines typically start generating power at5 m/s
  - Don't reach rated output until upwards of 10 m/s



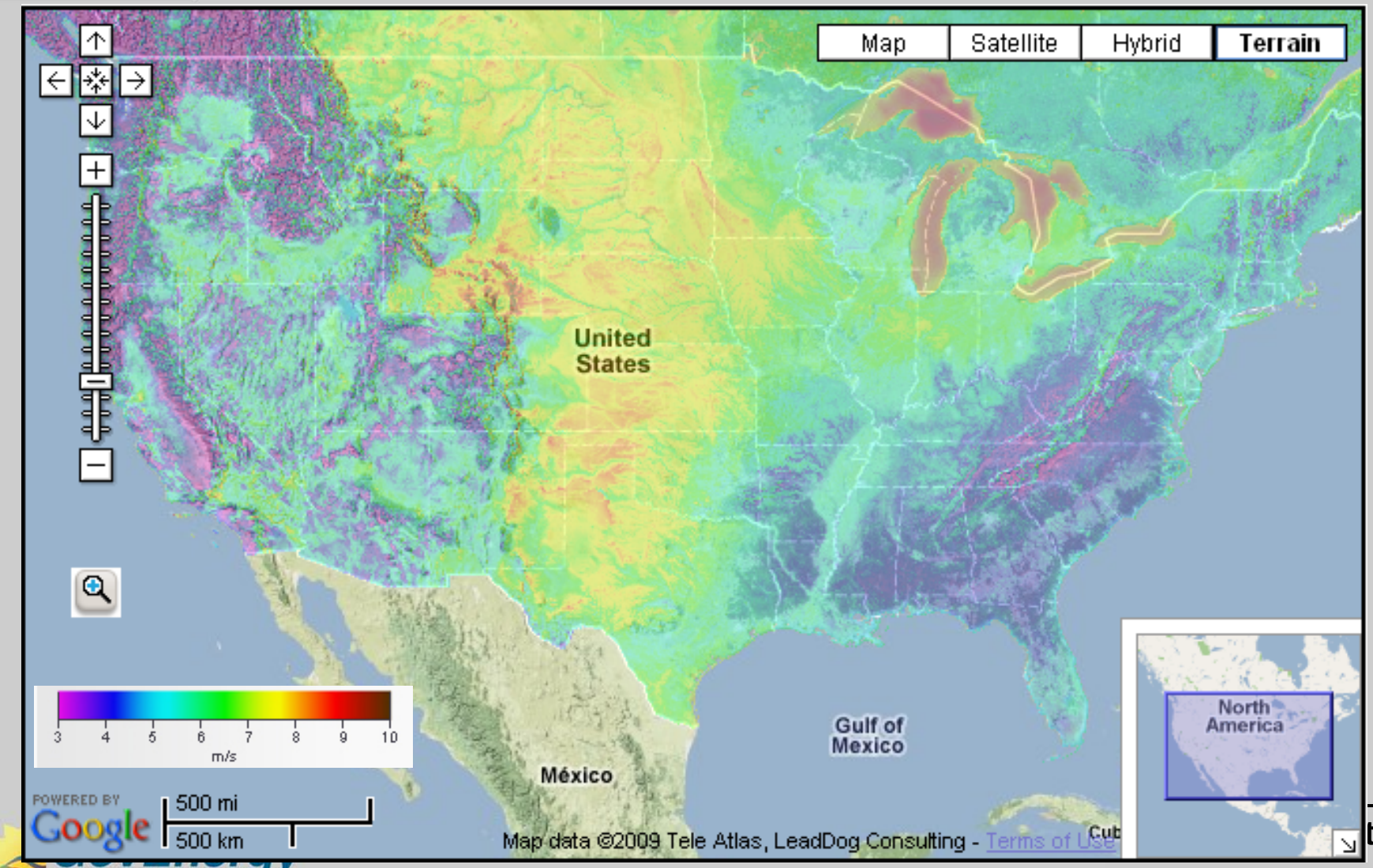
Northwind100 Power Curve: 21m
Standard Density (1.225 kg/m^3)

Vm (m/s)	Power (kWe)
1	0.0
2	0.0
3	2.2
4	5.2
5	10.1
6	17.3
7	27.3
8	42.1
9	58.1
10	70.4
11	80.7
12	88.7
13	94.2
14	97.6
15	99.6
16	101.3
17	102.3
18	102.6
19	102.5
20	102.0
21	101.3
22	100.3
23	99.3
24	98.3
25	97.5

Methods for Initial Assessment

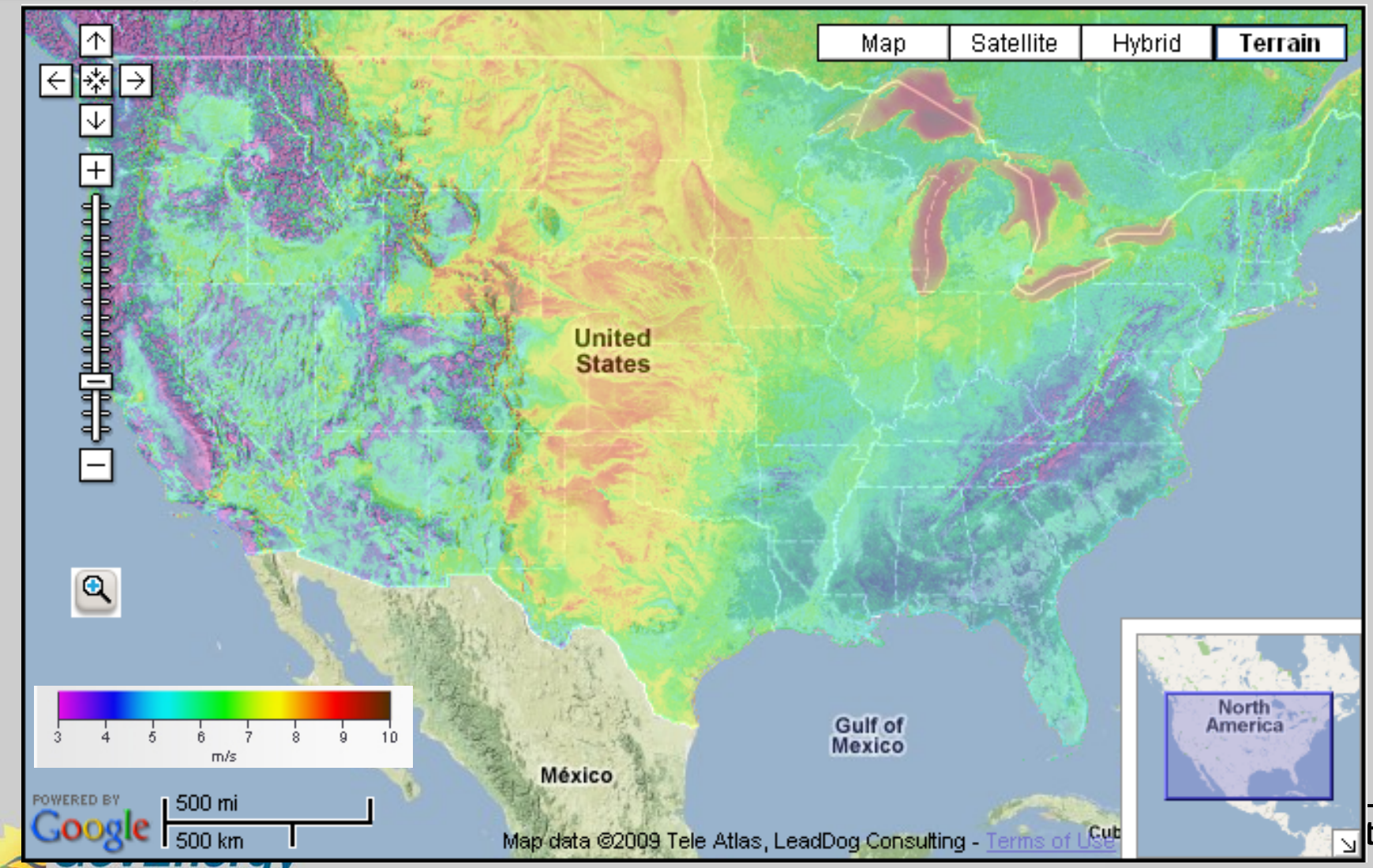
- Online wind maps, public wind data
  - limited accuracy, good for a first look
  - often will not meet mfr requirements
- "Virtual" data sets
- On-site data collection
  - Met tower ($), SODAR ($$$)
  - Requires open space, monitoring

Map of US Wind Speed, 60m

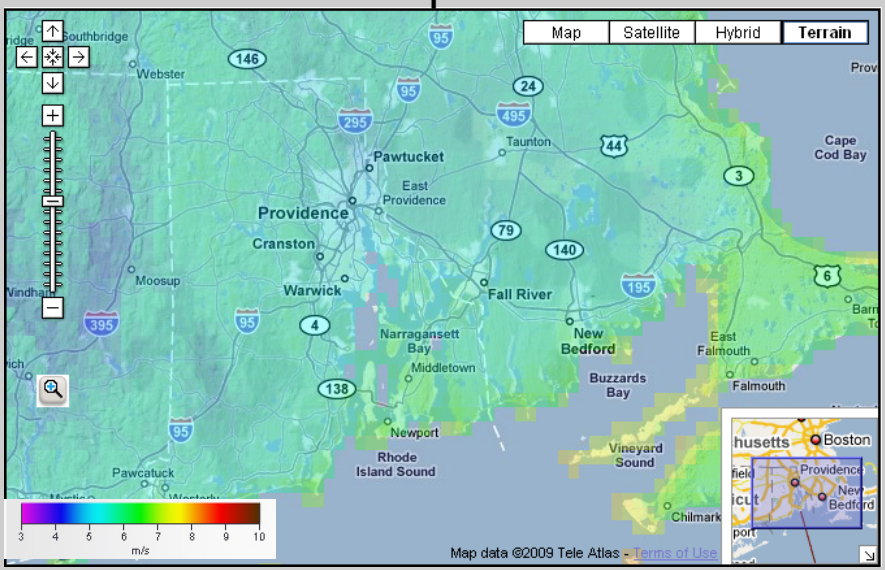


- AWS Truewind WindNavigator

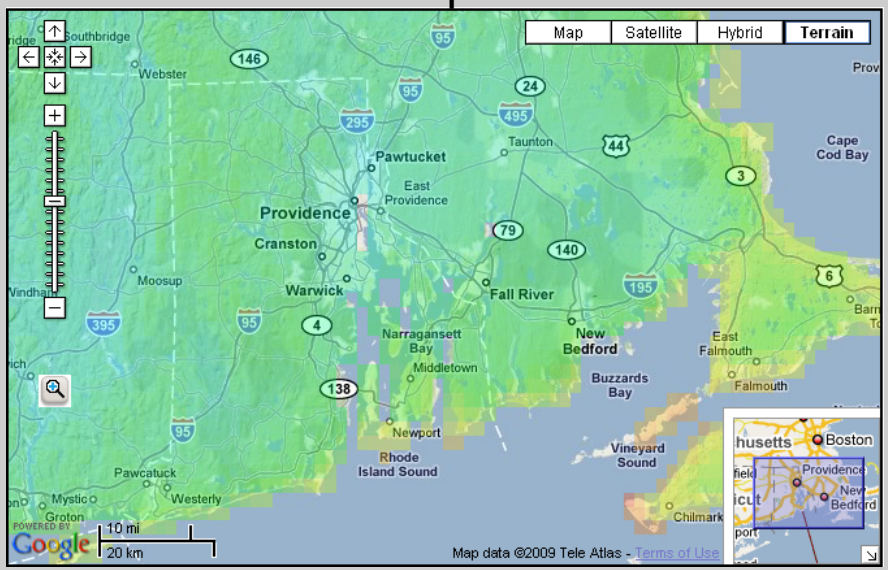
Map of US Wind Speed, 80m



Windspeed at 60m



Windspeed at 100m

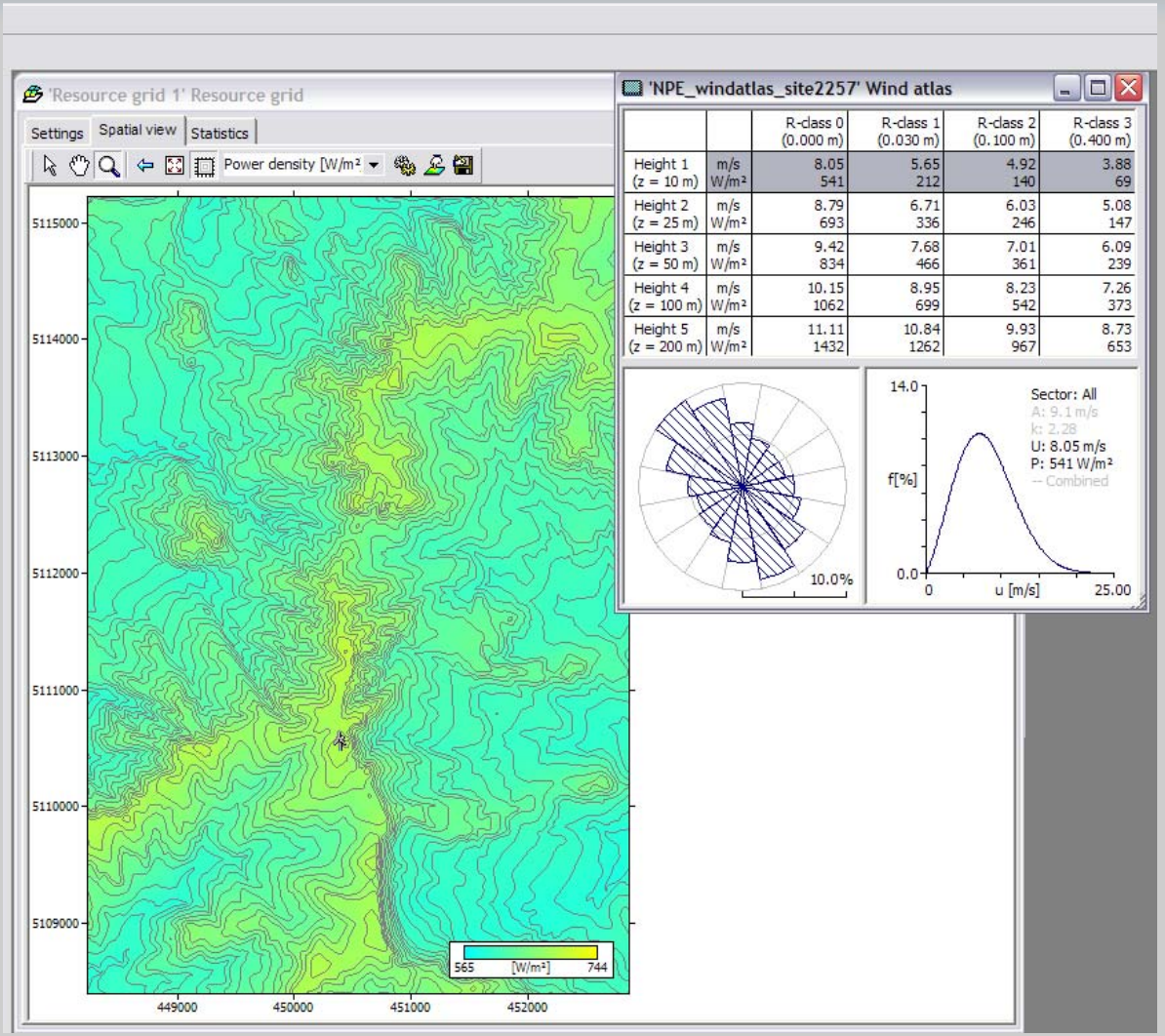


Providence: 4.88 m/s
Warwick: 5.11
New Bedford: 5.66

Providence: 5.45 m/s
Warwick: 5.72
New Bedford: 6.34

Once you have data

- Model the resource
  - Extrapolate point data over entire site
- Calculate annual energy production for single turbine location
- This is also useful if you are using reference data from a nearby location, or if you have obstacles in the vicinity of your turbine location.
  - WAsP

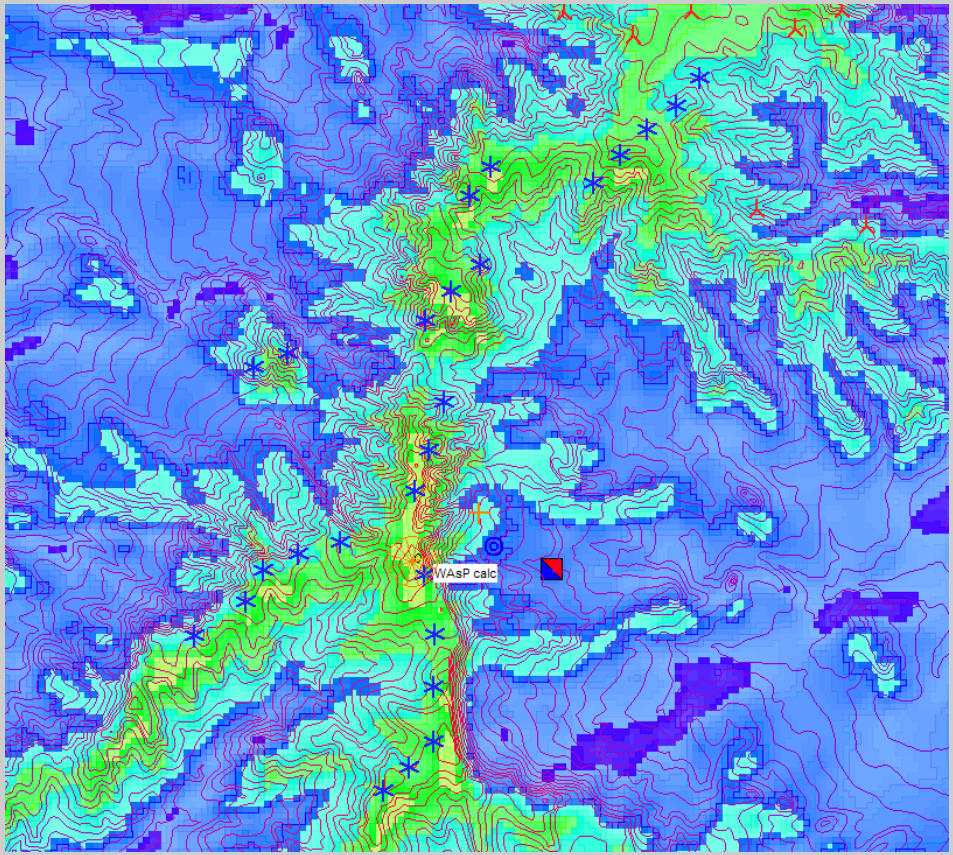


		R-class 0 (0.000 m)	R-class 1 (0.030 m)	R-class 2 (0.100 m)	R-class 3 (0.400 m)
Height 1 (z = 10 m)	m/s	8.05	5.65	4.92	3.88
	W/m²	541	212	140	69
Height 2 (z = 25 m)	m/s	8.79	6.71	6.03	5.08
	W/m²	693	336	246	147
Height 3 (z = 50 m)	m/s	9.42	7.68	7.01	6.09
	W/m²	834	466	361	239
Height 4 (z = 100 m)	m/s	10.15	8.95	8.23	7.26
	W/m²	1062	699	542	373
Height 5 (z = 200 m)	m/s	11.11	10.84	9.93	8.73
	W/m²	1432	1262	967	653

Array planning, optimization

- WindPro (& others) utilize the WAsP resource grid and performs complex energy calculations.
- Estimate energy production, calculate array losses, etc.
- Also allows for the creation of visual simulations, calculation of noise levels and visual impact.

Turbine	Yield [MWh]	Efficiency [%]
Siemens SWT-2.3-93 2300 92.6 !O! hub: 80.0 m	2,569	86.6
Siemens SWT-2.3-93 2300 92.6 !O! hub: 80.0 m	2,498	85.2
Siemens SWT-2.3-93 2300 92.6 !O! hub: 80.0 m	2,593	87.9
Siemens SWT-2.3-93 2300 92.6 !O! hub: 80.0 m	2,412	82.4
Siemens SWT-2.3-93 2300 92.6 !O! hub: 80.0 m	2,779	93.4
Siemens SWT-2.3-93 2300 92.6 !O! hub: 80.0 m	2,519	86



Types of turbines

- "Small" turbines: < than 100 kW
  - http://www.awea.org/smallwind/states.html
  - State policies and net-metering laws differ

Bergey 10kW

Entegrity 50kW

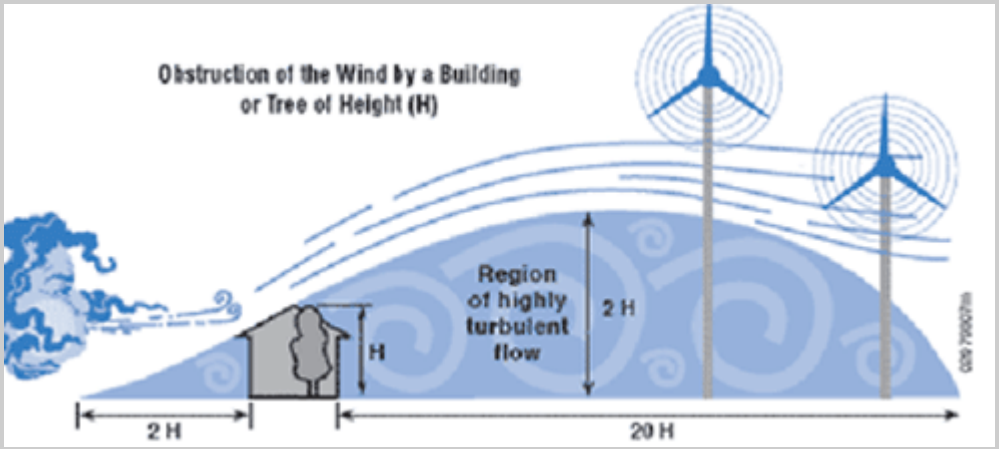
Northwind 100kW

WES 250kW

Furhlaender 600kW

WTGs in an Urban setting

- High turbulence
  - Trees, buildings
  - Slower wind
  - Wear & tear

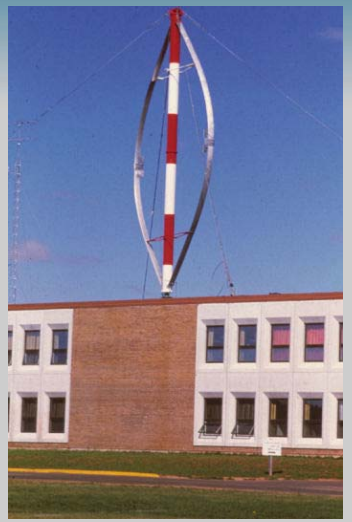


Source: US DOE

  - Suggest siting at least 30 ft higher than the highest object within 300 ft.

VAT & Building-mount

- General Issues to consider
  - Can roof support load of tower and turbine?
  - All turbines vibrate; vibration will be transmitted to the structure. Noise.
  - Wind immediately above the building will be more turbulent and slower velocity
  - Smaller turbines, less power produced



DAF-Indal Darrieus turbine on a school in eastern Canada circa 1980. Photo NRCan

Swift 1.5 kW wind turbine
Cut in: 3.6 m/s, peak at 11 m/s

Windspire 1.2 kW turbine. Cut in: 3.6 m/s, peak at 11.2 m/s
AEP at 5.4 m/s: 2,000 kWh.

www.wind-works.org

Basic Wind Economics

- Generally, ROI is better for larger turbines
  - Larger swept area, taller towers (faster wind)
  - More power produced, lower cost per kWh

- Seek to offset your energy costs, rather than sell power back to the grid
  - Retail vs. wholesale cost of electricity
  - No need to enter into Power Purchase Agreements

Cost Comparison for site in NY

Capital Cost of Turbines

	Bergey Excel 10 kW	Entegrity EW-15**	Fuhrländer FL 250****	Fuhrländer FL 600
Customs ($)	N/A	N/A	660,250	31,490
Turbine ($)	27,900	185,000		1,259,530
Tower* ($)	21,950			293,700
Transportation ($)	n/a	5,000		86,000
Installation ($)	10,000	50,000	200,000	300,000
Interconnect ($)	47,150	48,650	79,350	239,350
Contingency ($)***	21,400	57,730	187,920	442,014
Total Cost ($)	128,400	346,380	1,127,520	2,652,084
Total Cost ($/kW)	12,840	6,927	4,510	4,420

Simple Payback and Savings-to-Investment

		Annual savings			
WTG option	Capital Expenditures ($) *	RECs ($)	Electricity Savings ($)	Simple Payback (yrs)	Savings to investment Ratio
Bergey Excel – 10 kW	99,200	480	865	74	.014
Entegrity EW15 – 50 kW	285,180	2,760	5,954	33	.031
Fuhrländer FL 250 - 250 kW	1,005,680	14,905	32,037	21	.047
Fuhrländer FL 600 - 600 kW	2,652,084	52,616	110,316	16	.061

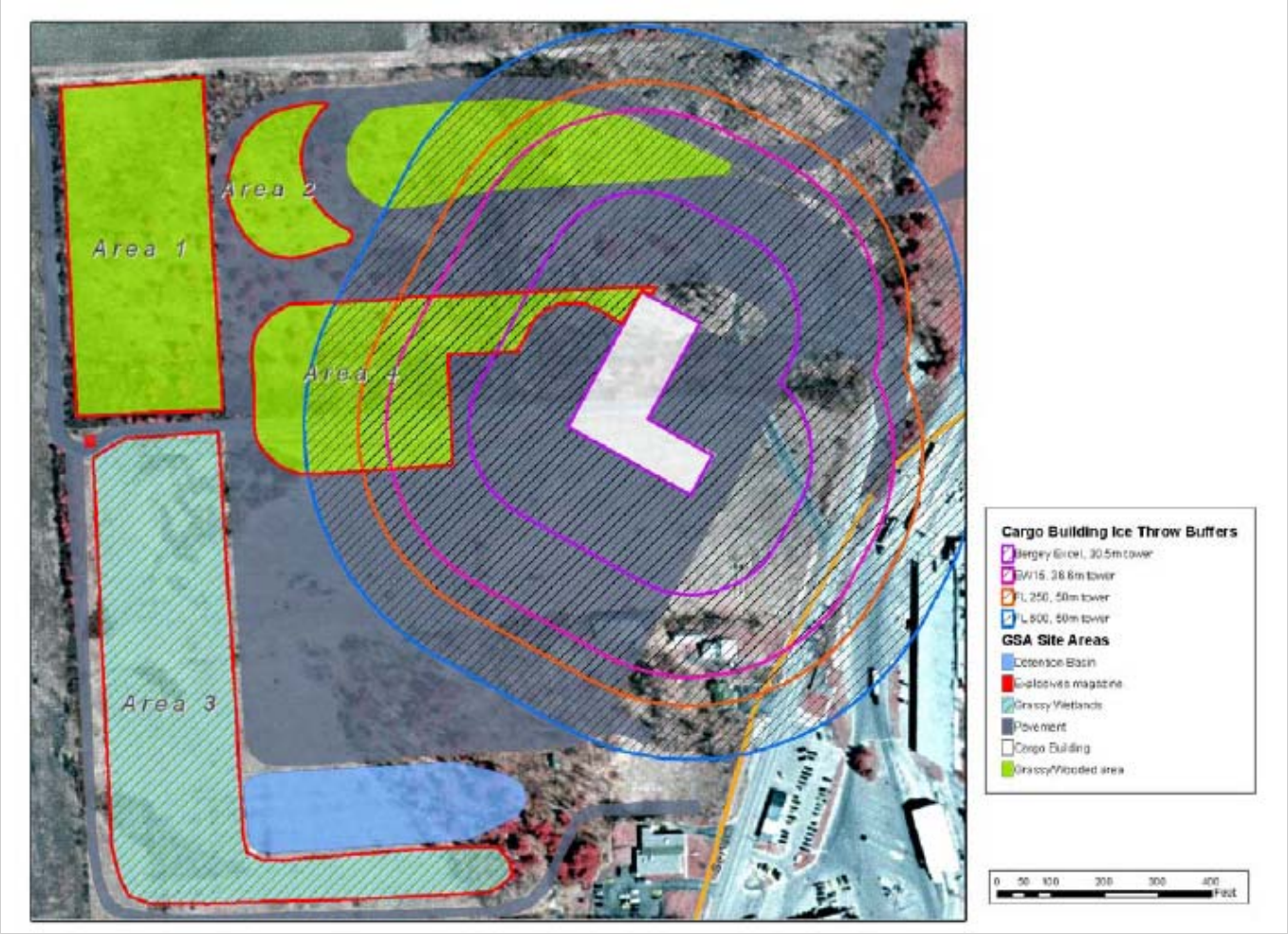
*Capital cost of turbine and equipment, less the NYSERDA rebate

Site Evaluation- Community

- Appropriate land use.
  - Flora, fauna
- Radar, communications signals, flight paths
  - Need to understand & mitigate potential impact
- Proximity to neighbors
  - Noise, shadow flicker, ice throw

Source/Activity	Indicative noise level dB (A)
Wind turbine, standing at base	50-55
Car at 40mph at 100m	55
Busy general office	60
Truck at 30mph at 100m	65

Setback Planning



Environmental Impacts

- Birds & Bats:
  - Urban, facility-proximate causes less habitat impact
  - Single turbine projects are less of an impact
- Noise
  - Generally, urban settings overshadow WTGs
- Shadow flicker
  - Not an issue for locations south of project
  - Can be predicted, modeled, often mitigated

Visual Simulation
Eight 3 MW sited over 1 sq mile

Visual Simulation

50kW turbine, seen from 2nd story window