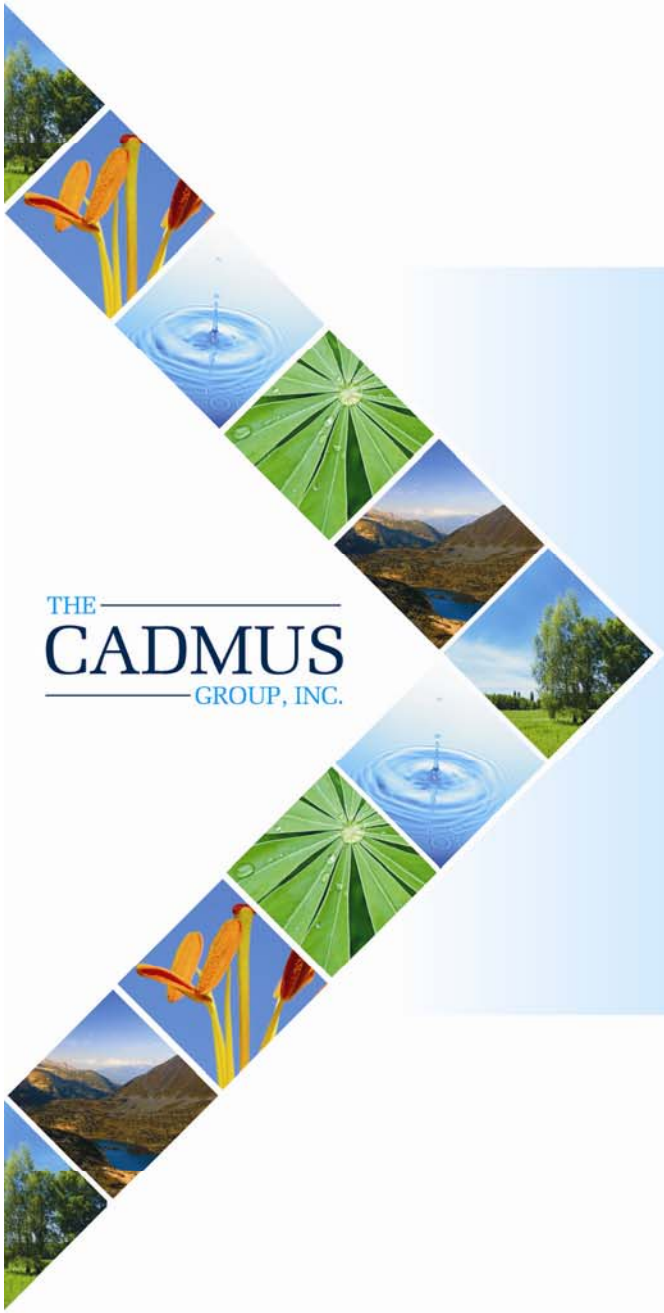

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Reducing Uncertainty in Resource Estimates for Massachusetts Wind Projects

Shawn Shaw
Charles McClelland

MA Wind Working Group
June 29, 2011

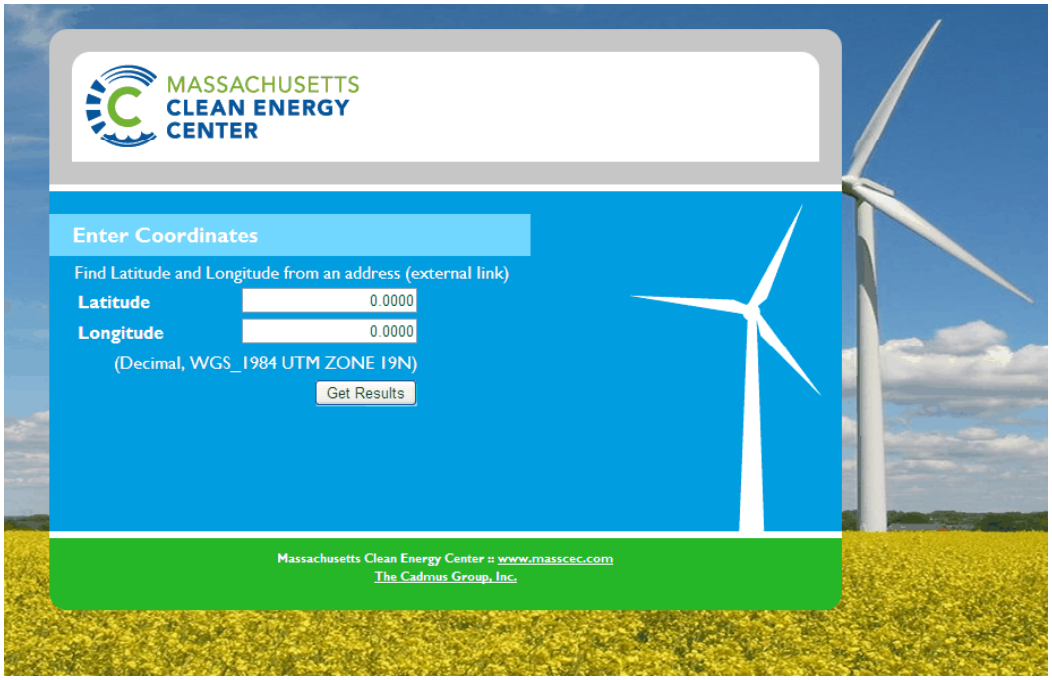
Wind Resource Prediction and Measurement in Massachusetts

- Commonwealth Wind Evaluation and Siting Tool (CWEST) required for all MassCEC grant applications
- Wind speed measurement for larger community and commercial wind projects
  - Mostly 50m-60m met towers
- Smaller projects (~100kW) generally rely on simulation and virtual met data

About CWEST

Developed to standardize site assessment, wind resource, and AEP estimation methods

Based on 2003 AWST Wind Maps
+
Effective ground level adjustment
+
Measured wind shear
+
Empirical wind speed adjustment
=
Wind speed estimate



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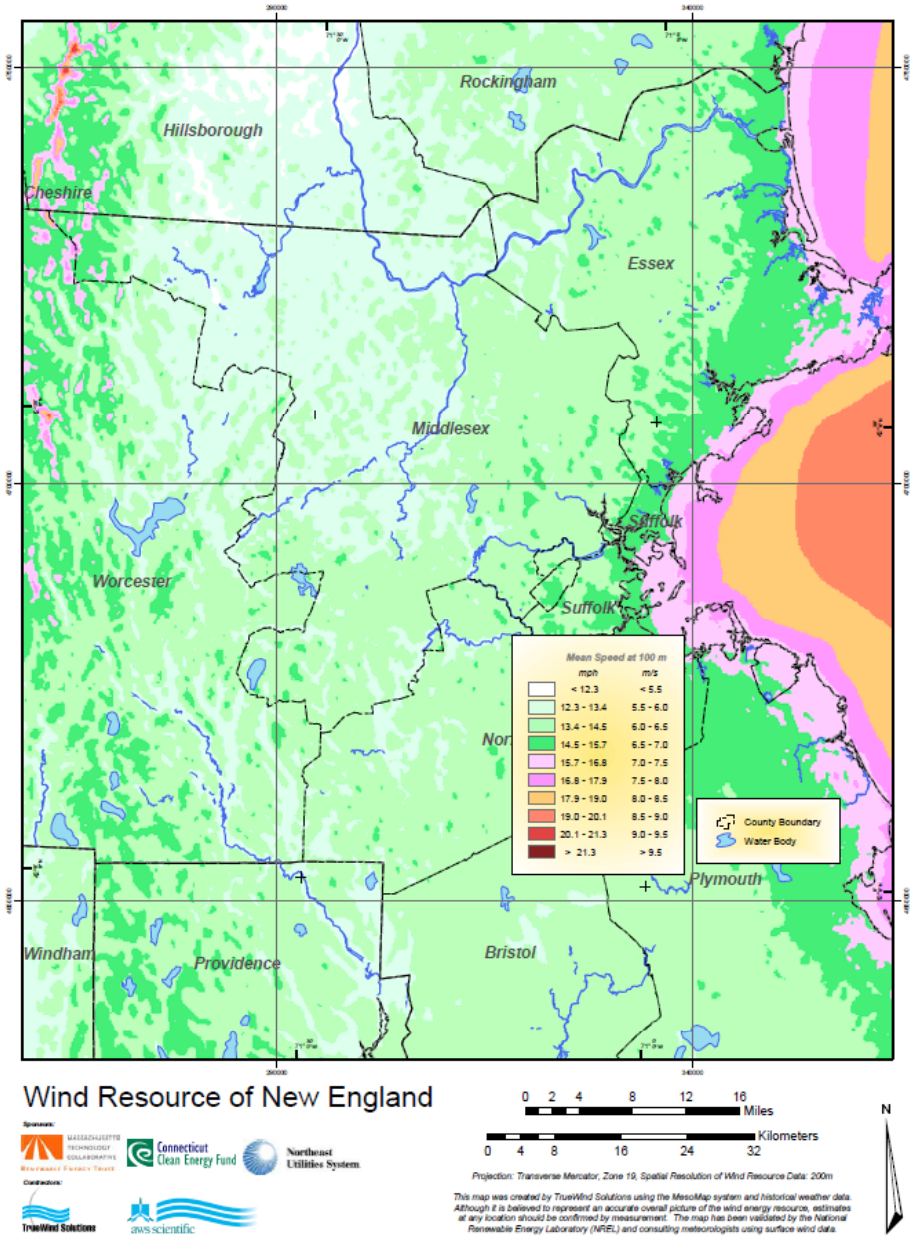
Review of New England Wind Map

- Created by AWS Truewind circa 2003
- Covers NE region (MA, ME, CT, RI, VT, NH)
- 200m x 200m wind speed grid resolution
- Wind speed probability distribution and wind rose
- Reported +/- 0.4 m/s



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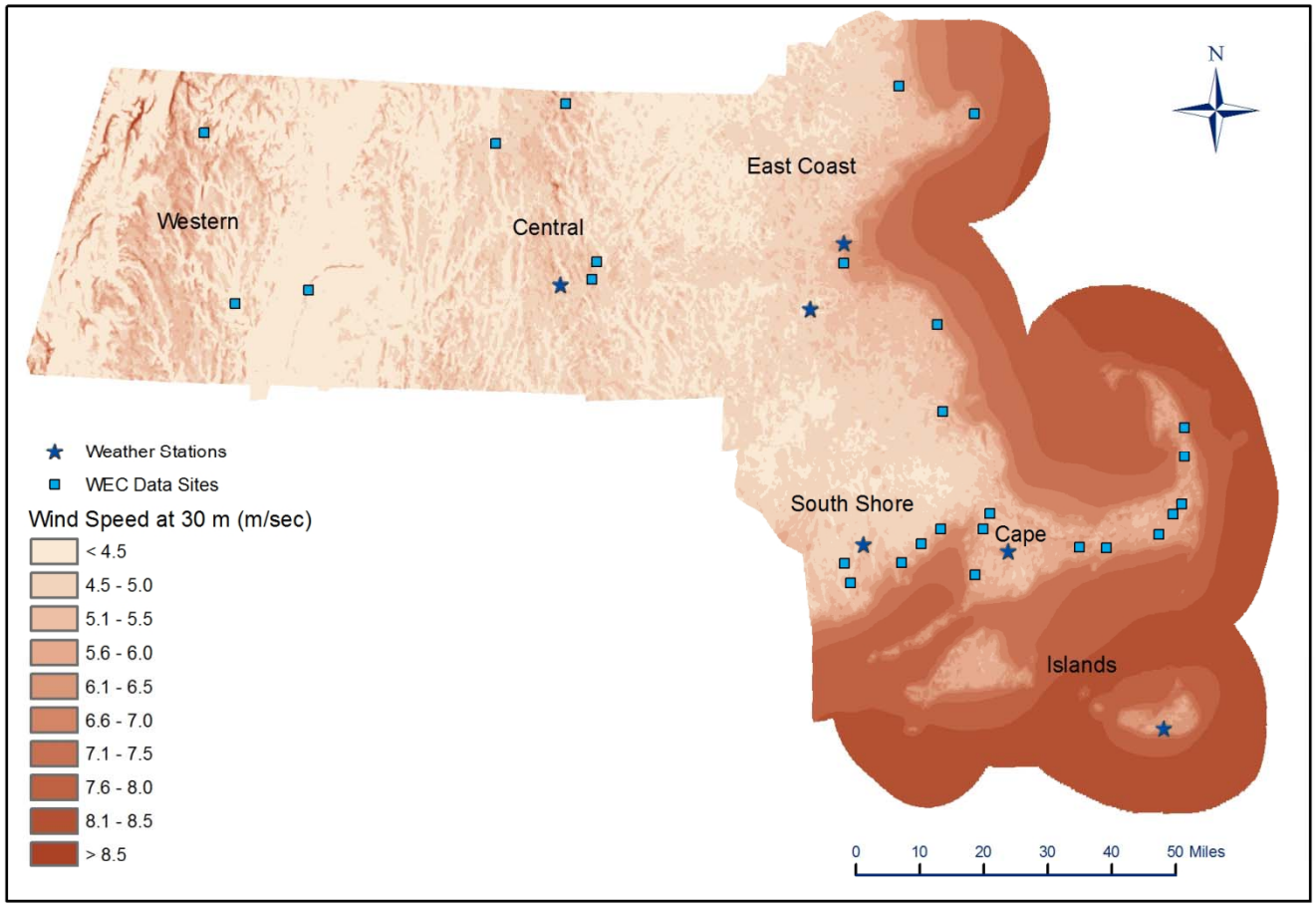
Cadmus Regional Wind Map Analysis

- 28 met tower sites
- Comparison w/ CWEST Wind Resource Report
- Normalized data according to:
  - Effective ground level
  - Long-term averages from national climactic data center (NCDC) sites

Sources of Wind Resource Data



6 NCDC weather stations

28 WEC met-data sites

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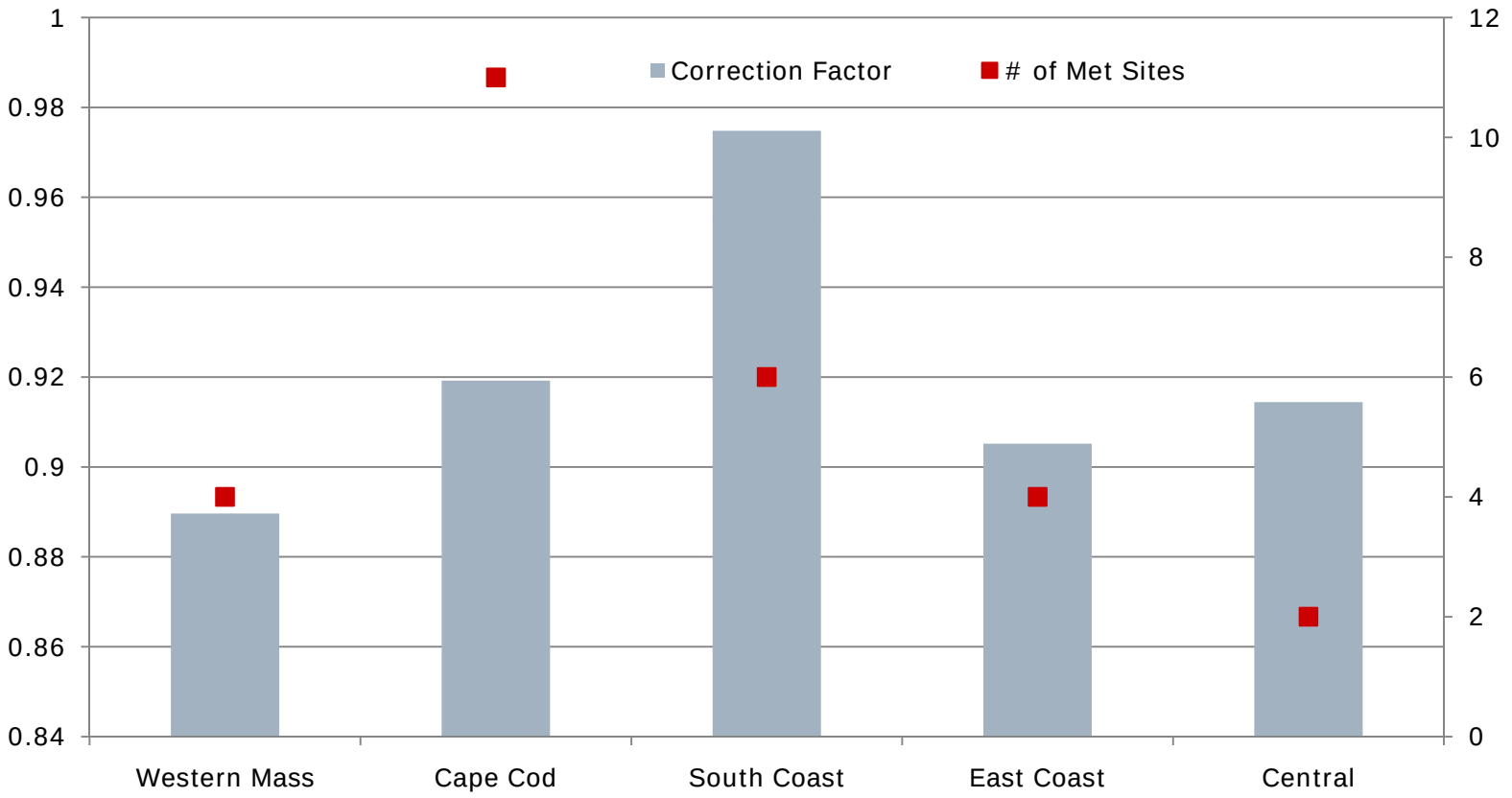
Met Tower Derived Adjustments to CWEST Wind Speed Predictions



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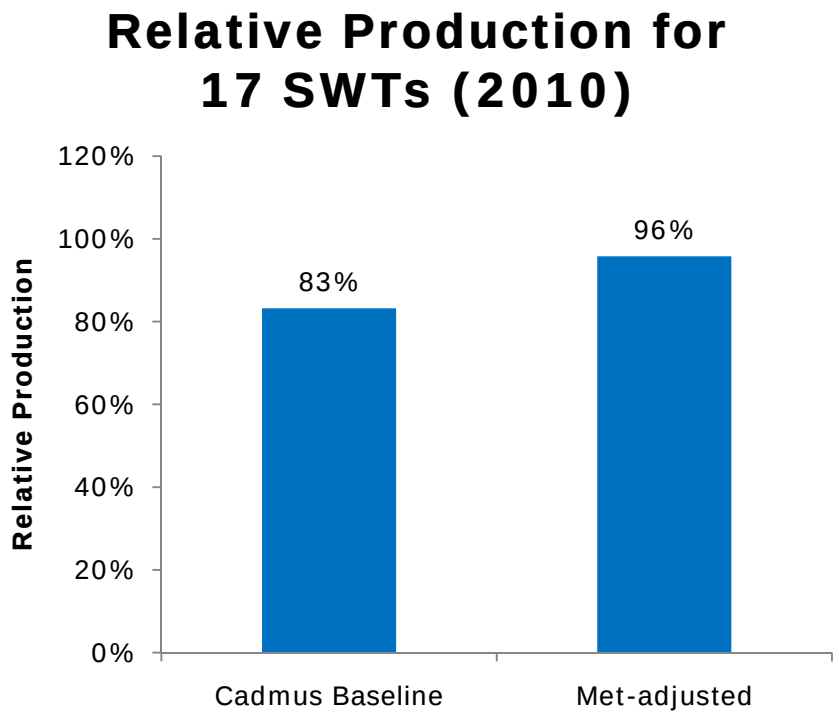
Modifying CWEST Wind Speed Estimates

- Regional adjustments to wind speeds range from 0.89 to 0.98
- In Cadmus' small wind evaluation, applying met tower-derived adjustments improved accuracy of AEP predictions by ~13%



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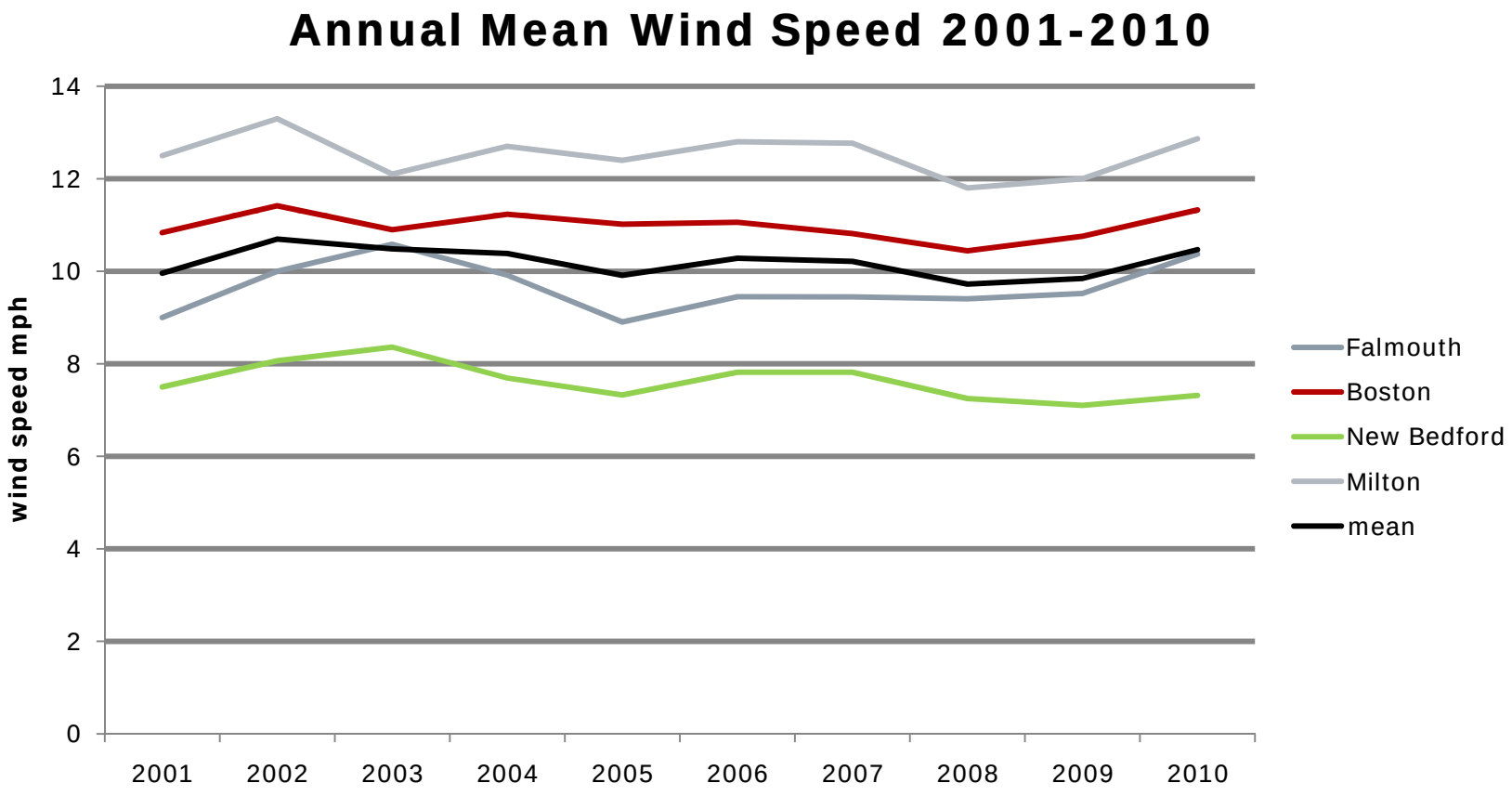
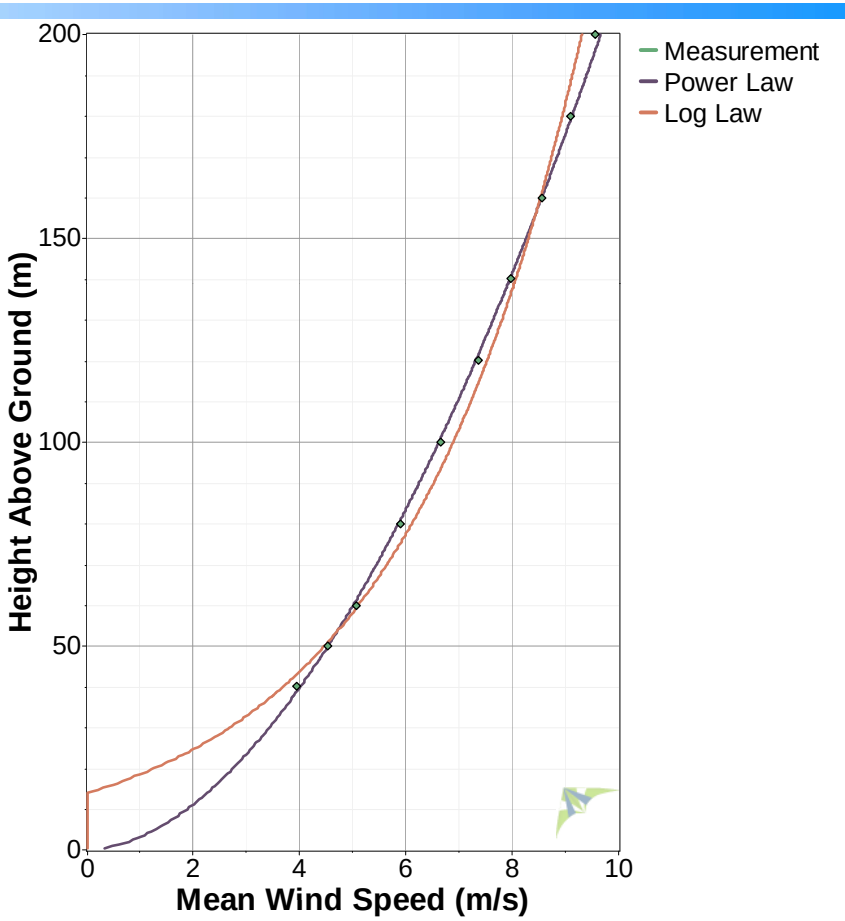
Annual Variability



Wind Shear 101

Wind Power Law

$$U_x = U_{ref}\left\{\frac{H_x}{H_{ref}}\right\}^{\alpha}$$

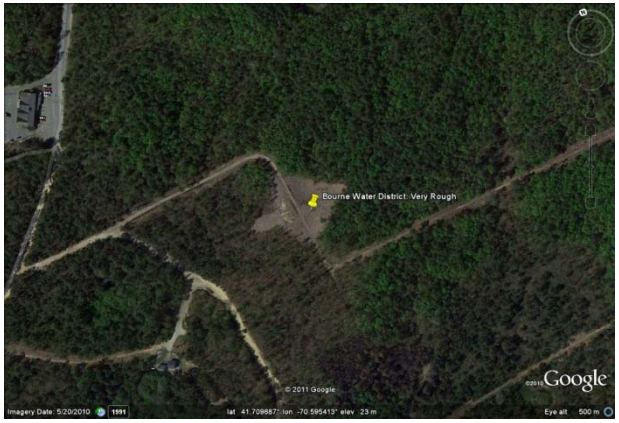


Wind Shear – Roughness Class Examples

WEC data sites grouped by terrain roughness:

Wellfleet: Moderate-Smooth – coastal, flat, shrubs

New Bedford WWTP: Moderate – coastal, flat, low buildings, sparse vegetation



Bourne Water District: Very rough– low hills, dense, old growth forest

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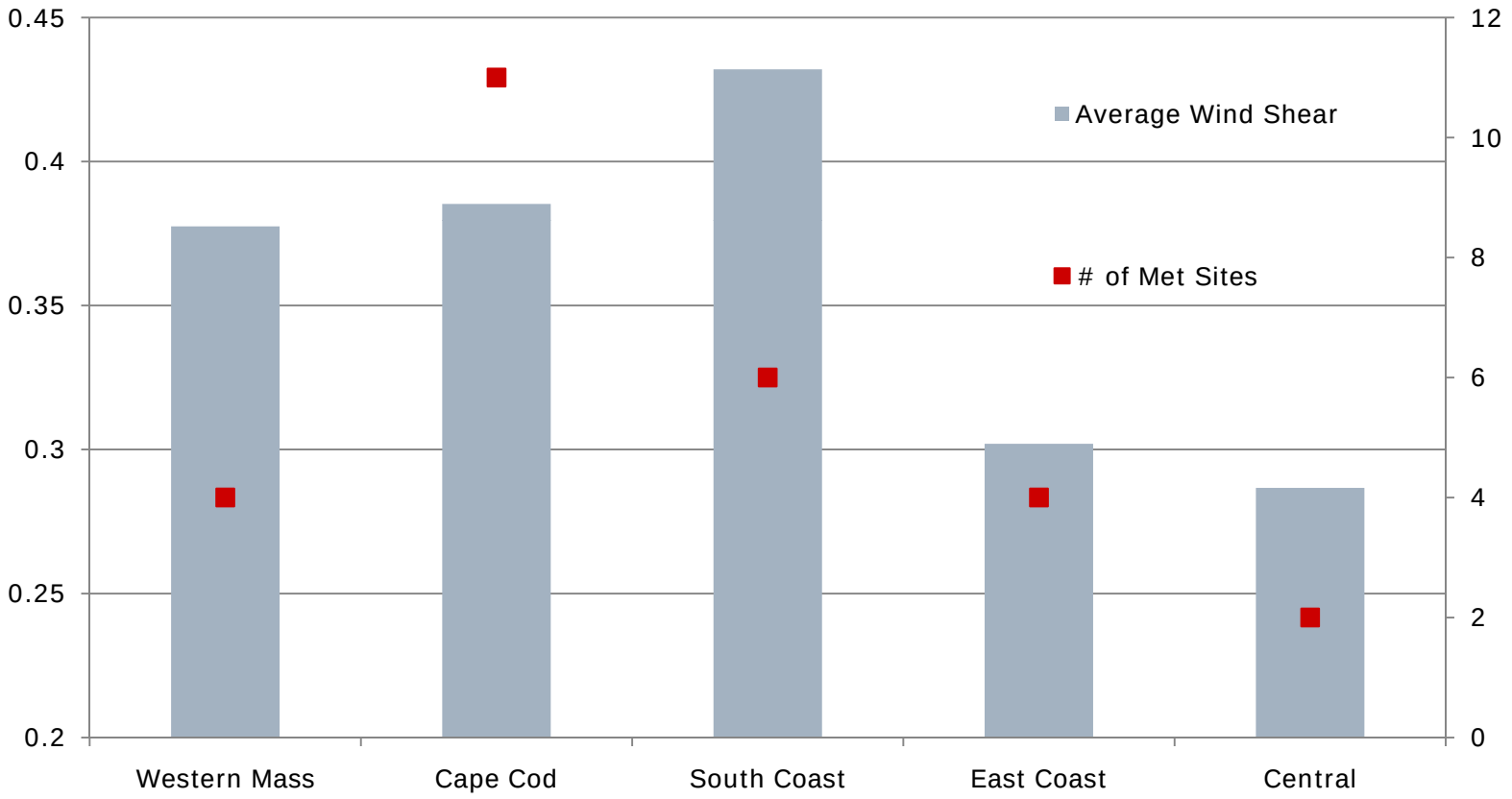
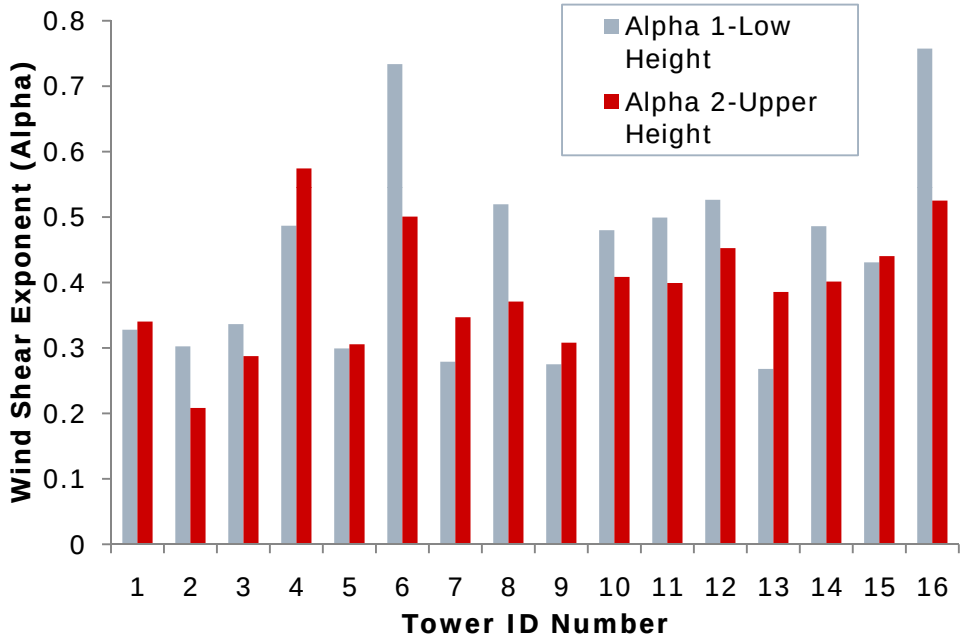
28 WEC data sites, average wind shear values, grouped by region

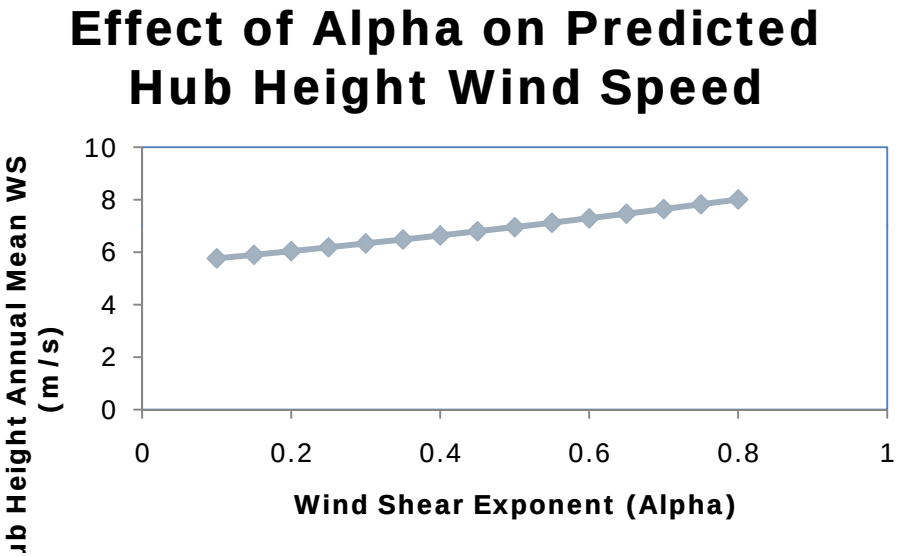


Wind Shear and Height

Height-Based Change in Wind Shear for 16 Met Towers		
General Terrain	Change in Alpha	N
Smooth-Moderate	-45%	1
Moderate-Rough	2%	1
Rough	-9%	8
Very Rough	-12%	6
Overall Average	-12%	16



Variable Wind Shear Influence on Hub Height Wind Speed



Approx 5% change in 80m wind speed per 0.1 change in Alpha

Base Height: 50m
Hub Height: 80m
50m Annual Mean Wind Speed: 5.5 m/s

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Case Study: Windville, MA

- Site considering utility-scale project
- South of Boston ~10 miles from coast
- 6 months of SoDAR Data (November 2010 – May 2011)
- MCP analysis used to adjust to annual values

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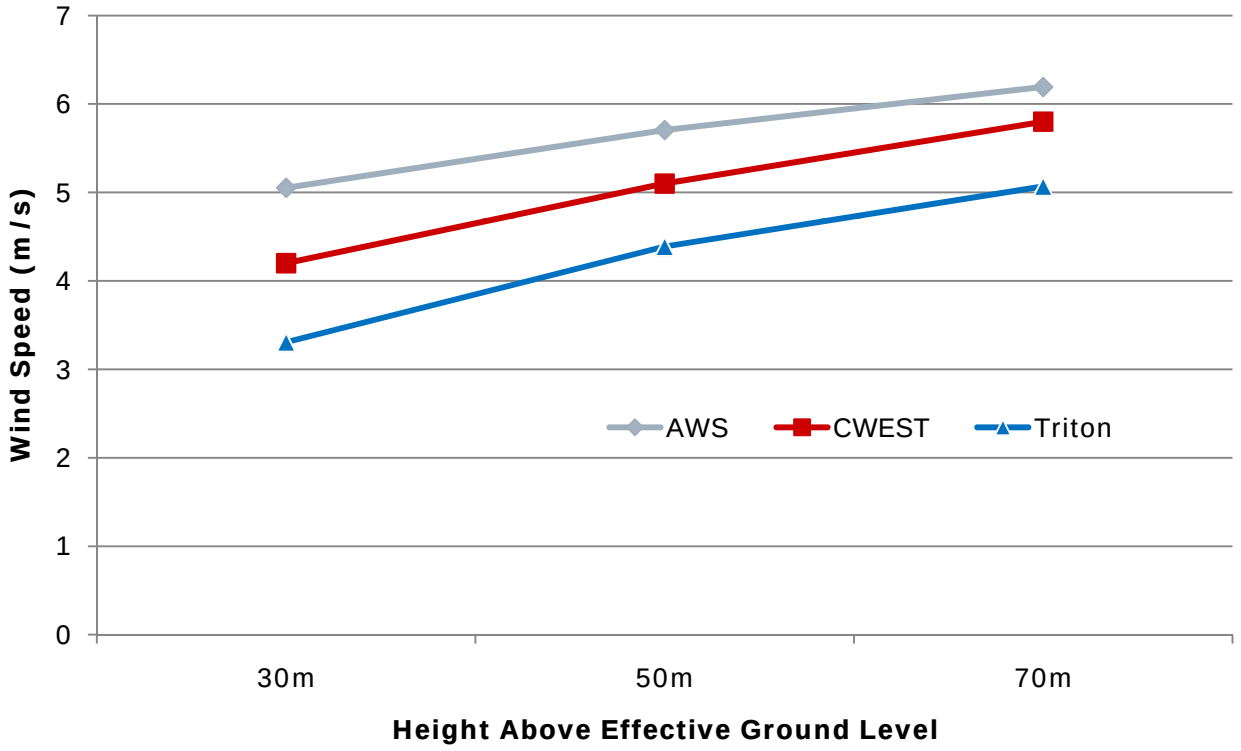
Why measure speeds onsite?
Wind Resource: AWS, CWEST, Triton



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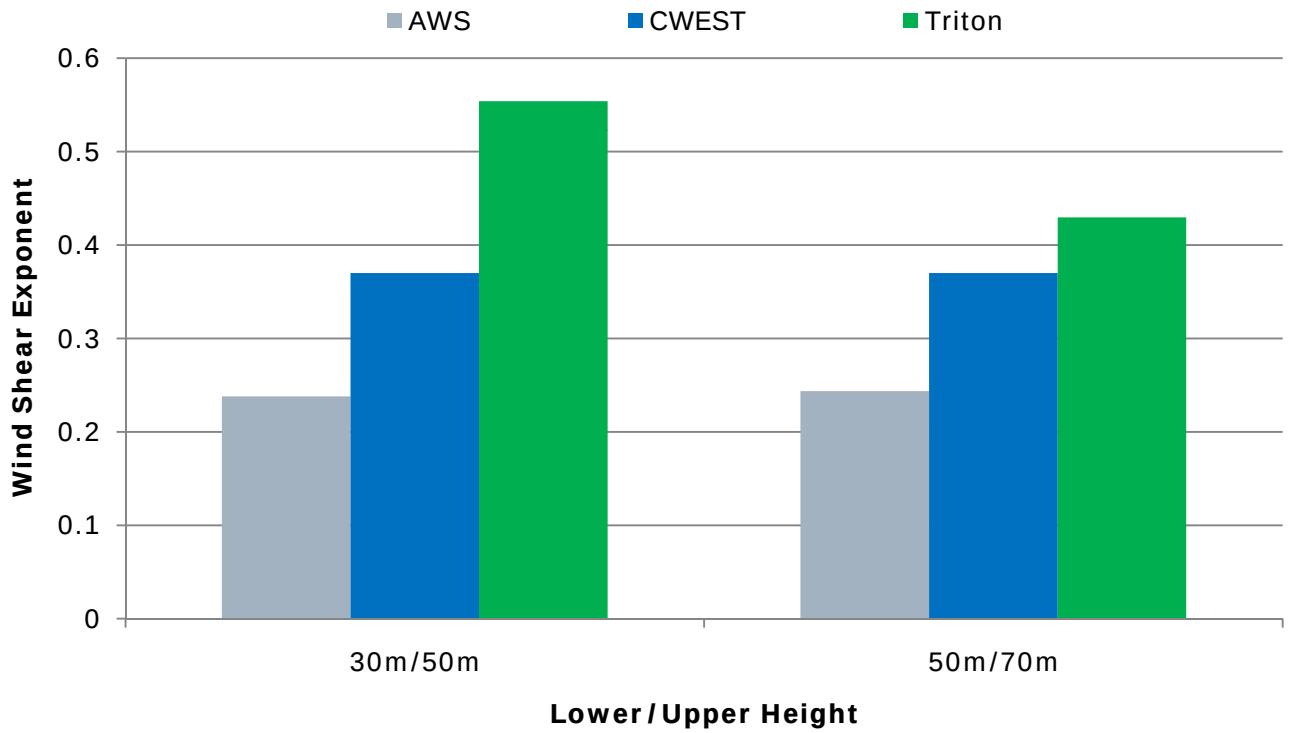
Comparison of Wind Shear Data Sources for Windville



AWST maps under predict wind shear by 57% and 43%.

CWEST under predicts wind shear at lower heights, and over predicts wind shear at upper heights.

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Wind Shear Impacts for Windville Site

Measured Wind Speeds	
Height AEGL (meters)	**wind speed (m/s)**
30	3.3
50	4.4
70	5.1

Measured Wind Shear	
lower/upper height	**alpha**
30m/50m	0.55
50m/70m	0.43

Estimated Wind Resource and AEP for Hypothetical 1.65MW turbine on 70m tower		
Source	**70m wind speed**	**AEP (Million kWh/yr)**
Estimate based on 30/50m shear	5.3	2.24
Actual measured value	5.1	1.97
% difference	**4.3%**	**13.7%**

→ Using estimated wind shear between 30 and 50 meters resulted in a performance overprediction of about 14%.

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Conclusions

Prospecting and Small Projects

- Wind map predictions optimistic but regional adjustments can help improve accuracy of estimates
  - 5%-10% sufficient for most regions

Larger Projects

- Wind shear changes with height and can cause inflated AEP estimates if not considered
  - Especially important for rougher sites
  - Spot measure shear with SODAR
  - Stepwise shear calculation

Thank You

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