

Structure and Role of Incentive Programs in Small Wind

NESEA Building Energy
March 9, 2011

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Agenda

1. MassCEC overview
 2. MassCEC small wind goals
 3. History
 4. Small wind principles in incentive programs
 5. Micro Wind program
 6. Progress to date
 7. Siting and installation issues
(Charles McClelland, the Cadmus Group)
 8. Conclusions and next steps
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MassCEC Areas of Focus

Idea Research Development Manufacturing Project/Installation



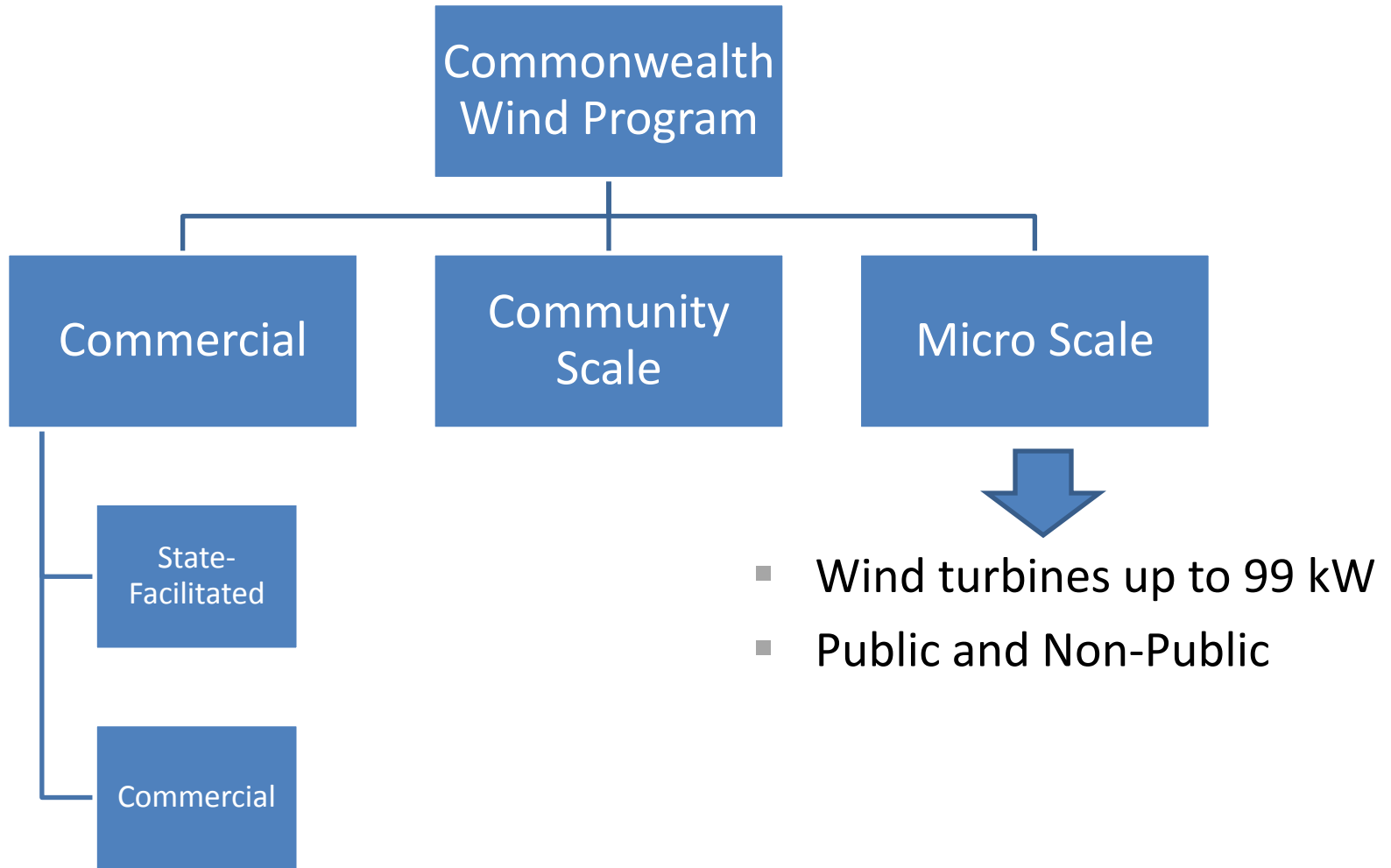
**Clean Energy
Sector
Development**

**Investments in Clean
Technology**

**Renewable
Energy
Generation**

Workforce Development

Commonwealth Wind



MassCEC Small Wind Goals

Mission: To support the installation of well-performing and responsibly-sited projects using commercially-proven small wind technologies

We believe that small wind is a viable DG technology, though applicable in fewer locations than solar PV

www.masscec.com/microwind



MassCEC Small Wind Goals

How do small wind projects fit in with DG in MA?

- “Resource Scarcity”
 - Land & Zoning
 - Wind Resource
- Economic viability highly dependent on performance
 - Performance uncertainty is much larger than with PV
- Small wind “competes” with solar
 - Different incentives, greater predictability



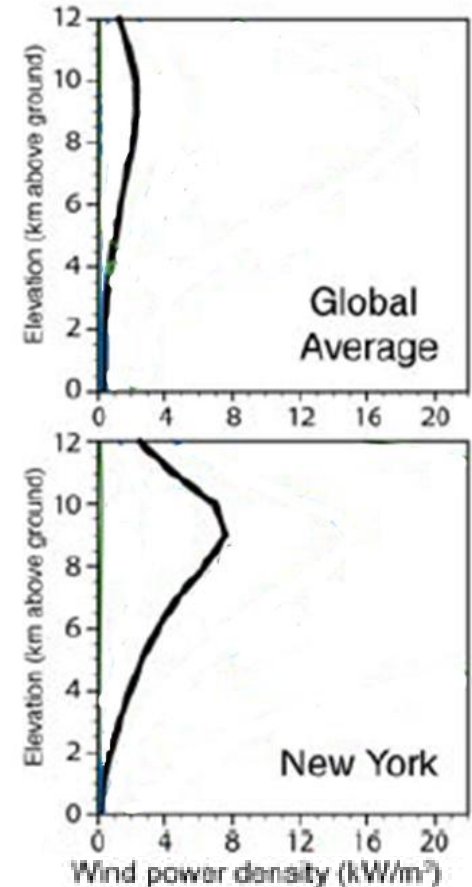
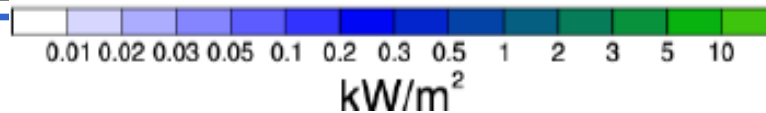
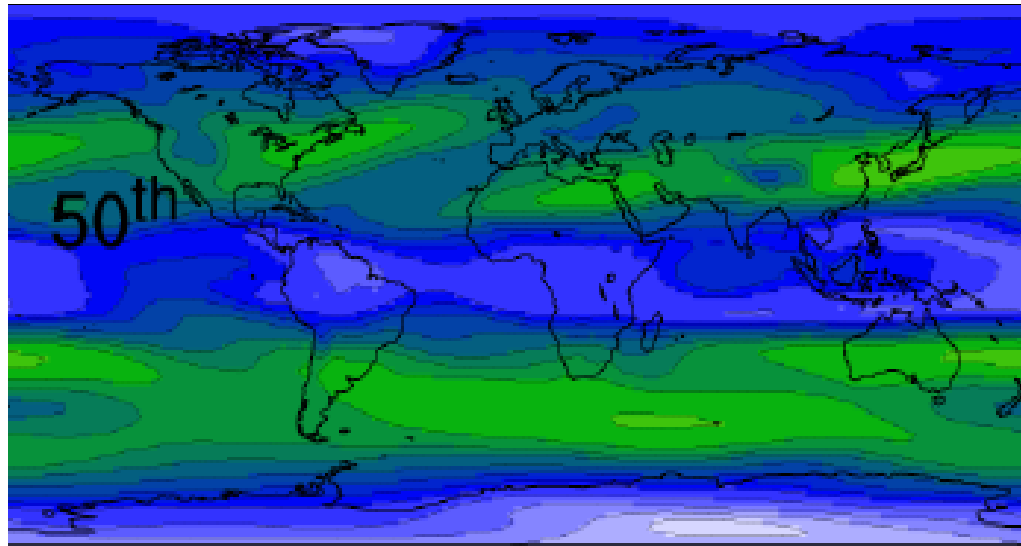
A Brief History

- **2005:** Small Renewables Initiative launched.
- **2006 – 2007:** WindTechCo installations.
- **2008:** Cadmus evaluates small wind performance. Conclusions identify significant underperformance.
- **Early 2009:** Micro Wind launched.
- **2009:** Economic Crisis. ITC expanded. Small Wind Certification Council standard unveiled.

What's next?



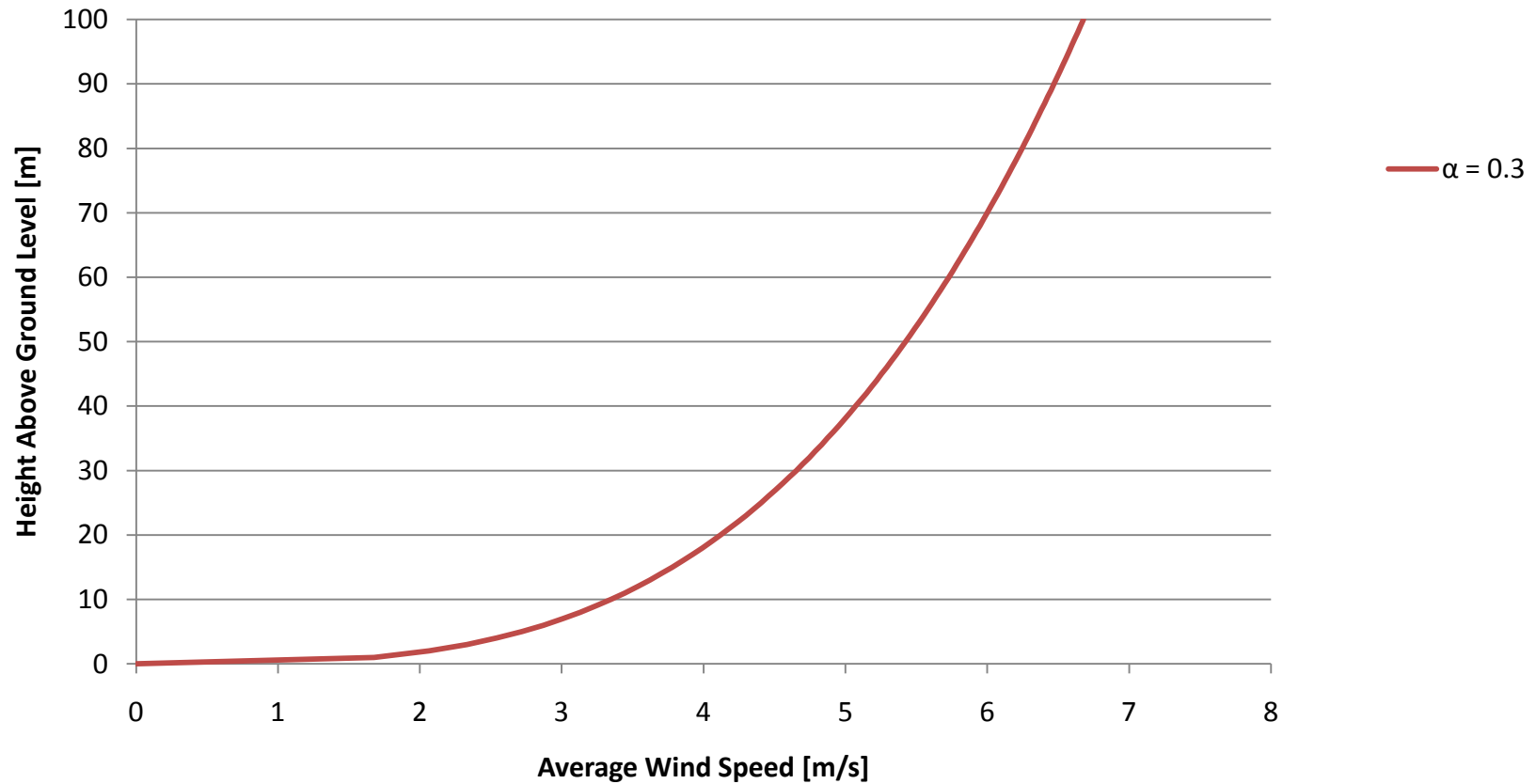
High-Altitude Wind Power?



Archer, C; Caldeira, K. Global Assessment of High-Altitude Wind Power. *Energies*. 2009, 2, 307 – 319.

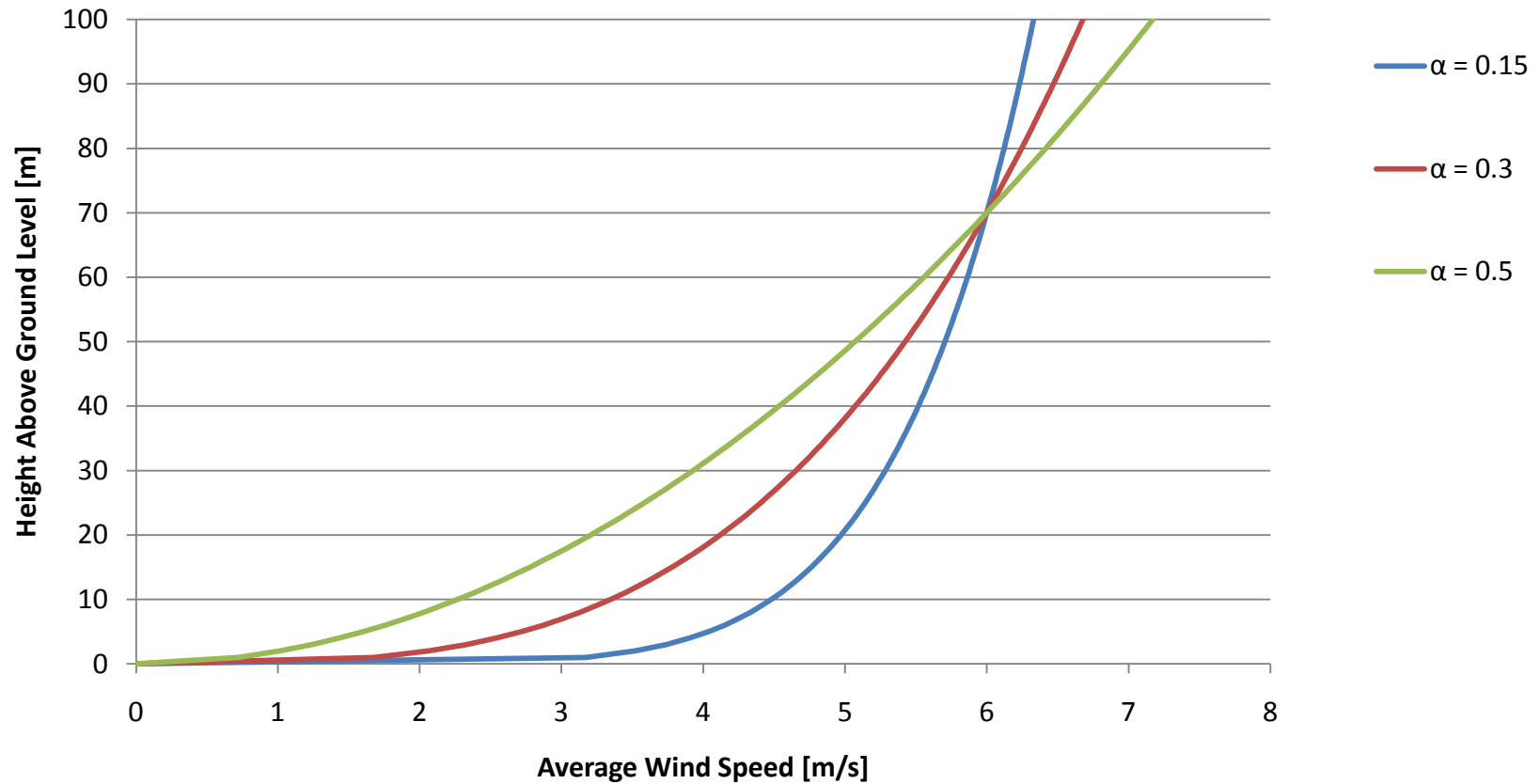
Incorporating Small Wind Principles in MA

Typical Wind Profiles from a 70m Wind Map



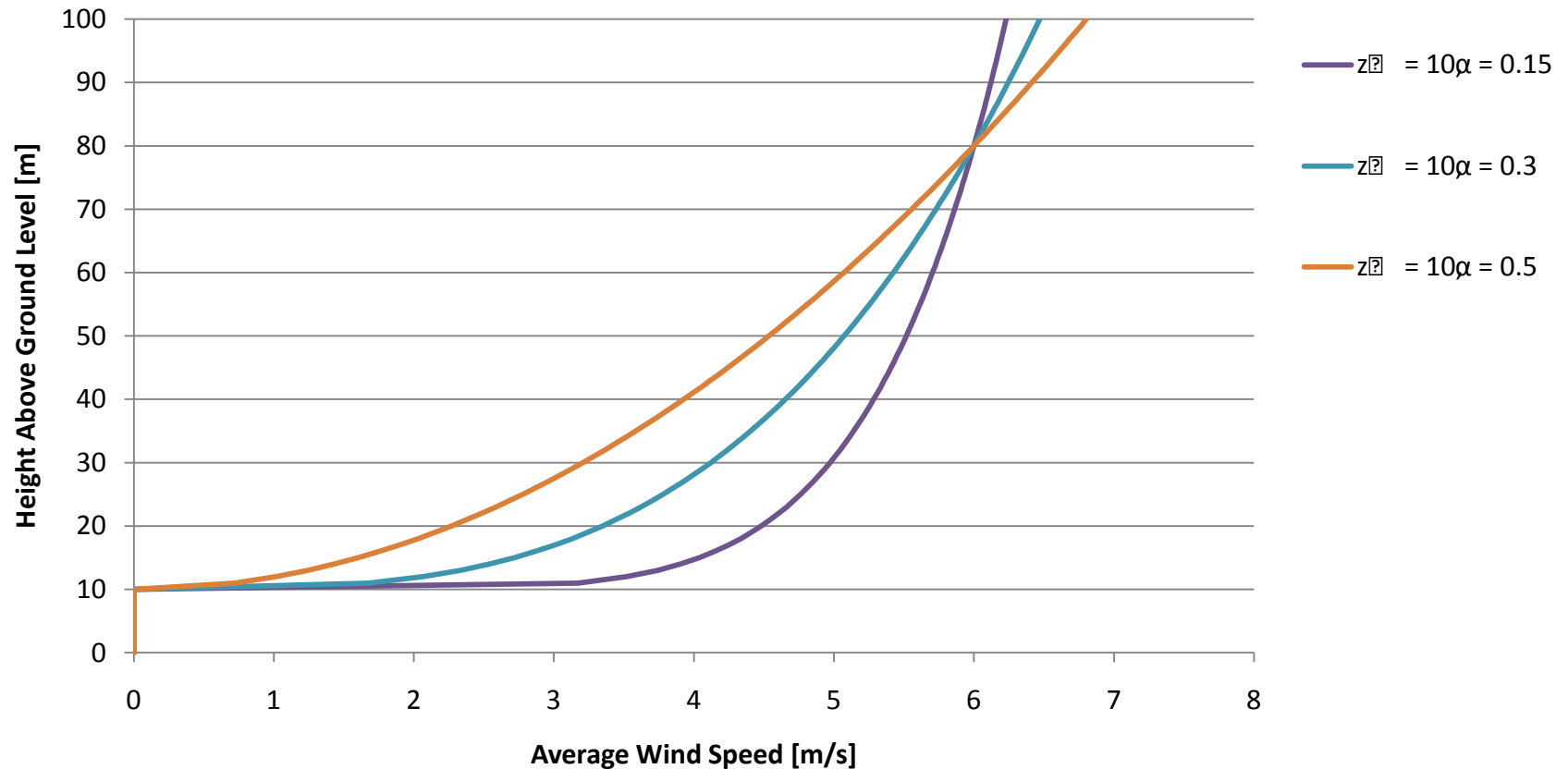
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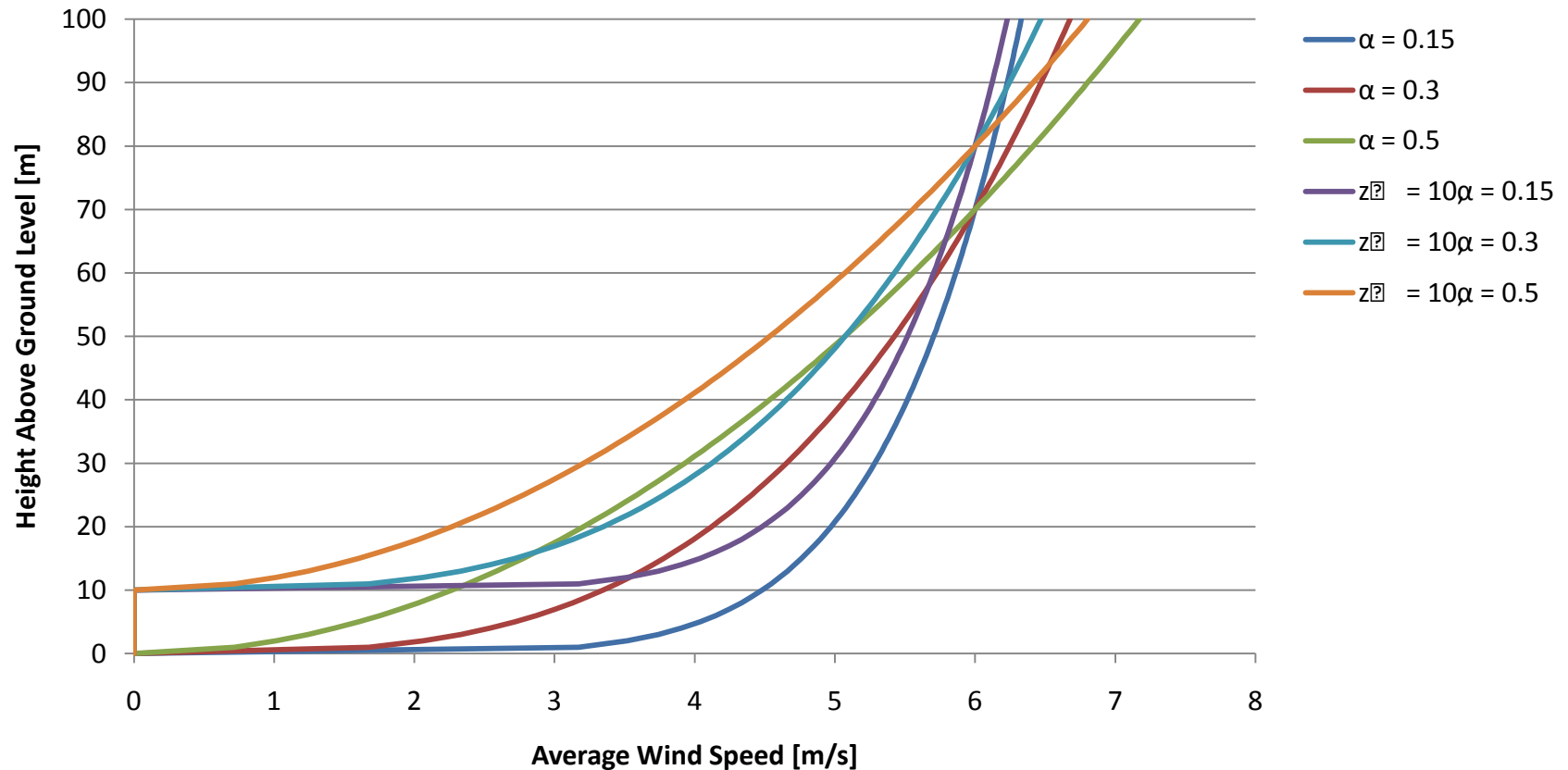
Incorporating Small Wind Principles in MA

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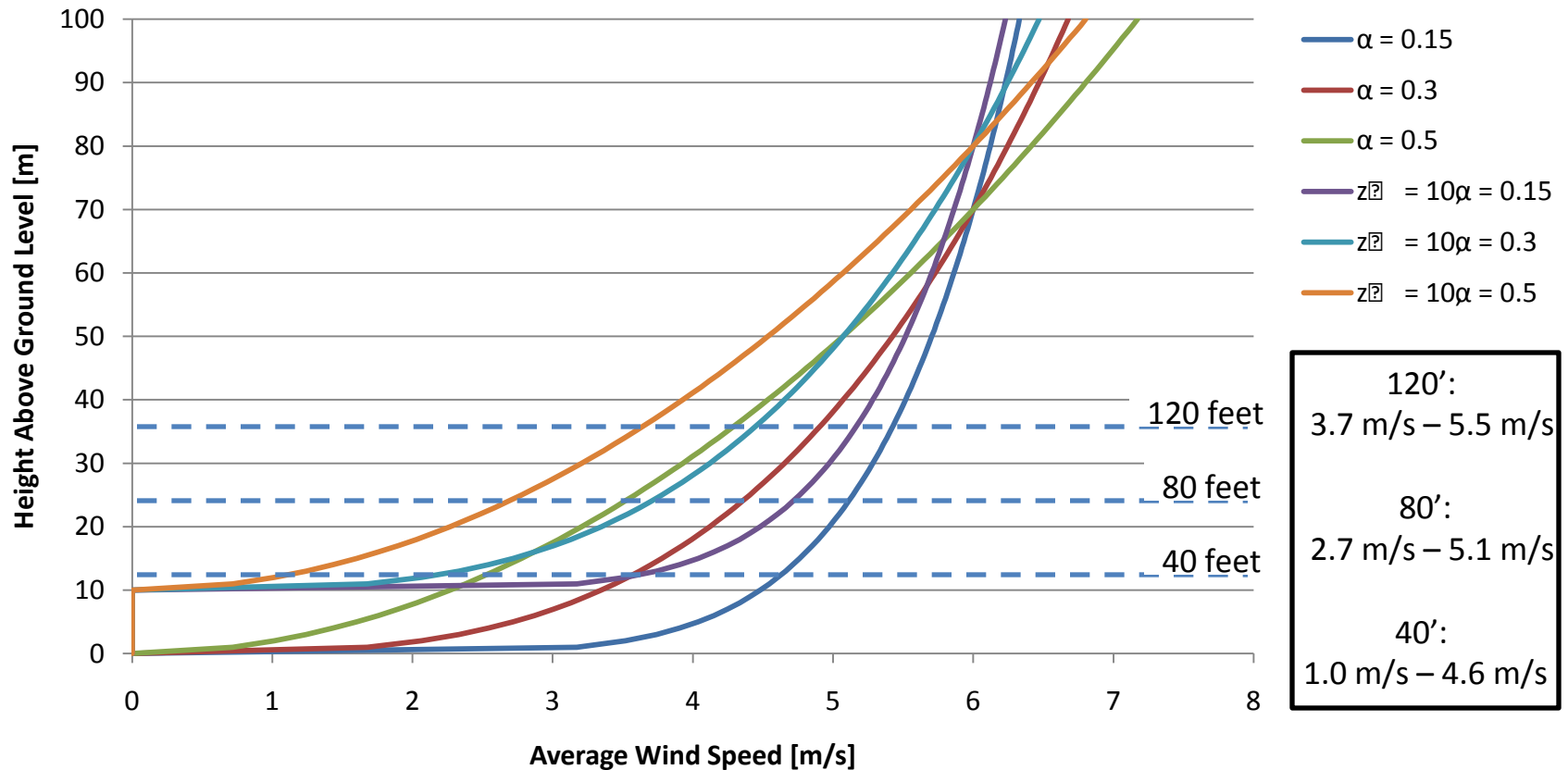
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Typical Wind Profiles from a 70m Wind Map



Incorporating Small Wind Principles in MA

Typical Wind Profiles from a 70m Wind Map



Incorporating Small Wind Principles in MA

Extreme Wind Speeds

- Designing for low average wind speeds and high extreme wind speeds
- Eastern New England susceptibility to hurricanes
 - Requires robustly designed turbines
 - Sometimes have to compromise on rotor diameter

Zoning

- Multiple levels of review (local, regional?)
 - Uncertainty in outcome during early planning and investment
 - Increase in authority from regional planning agencies (e.g. Cape Cod Commission, MV Commission)
-

Design of the Micro Wind Program

- Construction rebates available for qualifying projects
- Minimum performance threshold of 10% capacity factor
- Wind turbines must be independently tested for performance, reliability, and safety
 - Small Wind Certification Council (SWCC)
 - NYSERDA Small Wind List
 - IEC 61400 Certification
- All systems are independently inspected
- All systems incorporate onsite wind and production monitoring



Micro Wind Rebates

- Rebate is dependent on both turbine capacity [kW] and expected performance [kWh per year]
- Rebate paid 90% after project installation and 10% after 12 months

Non-Public Micro Wind Incentives [\$ /kW]

Capacity [kW]	Capacity Factor			
	10%	15%	20%	25%
1 kW	\$4,000	\$4,000	\$4,000	\$4,000
5 kW	\$2,638	\$3,407	\$4,000	\$4,000
10 kW	\$2,038	\$2,667	\$3,296	\$3,925
50 kW	\$1,313	\$1,707	\$2,000	\$2,000

Small Wind in MA: Results to Date

Small Wind Systems Installed by Year

Year	Systems Installed	Cumulative Systems Installed	Capacity Installed [kW]	Cumulative Capacity Installed [kW]	Cost (\$/W)
2004	2	2	10.40	10.40	\$15.00
2005	2	4	2.74	13.14	\$11.66
2006	4	8	13.30	26.44	\$8.32
2007	15	23	120.00	146.44	\$6.79
2008	23	46	161.15	307.59	\$8.32
2009	20	66	188.10	495.69	SRI: \$7.45 Micro: \$8.56
2010	9	75	134.56	630.25	SRI: \$7.46 Micro: \$5.69
2011*	5	80	90.80	721.05	NA

*Includes Pipeline

Technical Consultants

The Cadmus Group acts as primary inspector of “micro scale” wind and solar systems on behalf of the MA Clean Energy Center.

- Inspected over 40 small wind systems on behalf of MassCEC since 2008.

Ensure installers are adhering to industry-accepted best practices:

- Electrical Code Compliance (2008 Massachusetts Electrical Code)
 - Optimal Performance (siting guidelines, production estimates)
-

Electrical Violations: Harvard



System Location: Harvard

System: Bergey Excel-S (2) 10 kW, grid-tied

Inspection Date: 12/18/2009

Violations: overloaded bus bar, labeling

Service:	200 A
WTG Back	
Feed Breakers:	120 A

Sum:	320 A

→ Exceeds 120% of
Busbar Rating (250
Amps)



705.12 Point of Connection
D. Utility Interactive Inverters
(2) Bus or Conductor Rating.
The sum of the ampere ratings of overcurrent devices in circuits supplying power to a busbar or conductor shall not exceed 120 percent of the rating of the busbar or conductor.

(2008 National Electrical Code)

Electrical Violations: Harvard



System Location: Harvard

System: Bergey Excel-S (2)

Inspection Date: 12/18/2009

Violations: overloaded bus bar, labeling



ABOVE: Photo of bus bar showing two relocated 60-amp breakers and appropriate labeling.



LEFT: Photo of turbine disconnect. A new sticker has been affixed, as well as a label indicating that the over-current device has been reduced to accommodate renewable energy sources.

Energy Estimates: CWEST

CWEST (Commonwealth Wind Evaluation and Siting Tool)

- Developed by Cadmus to assist customers and installers with the evaluation of candidate wind sites
- Became requirement for MassCEC Micro Wind application in late 2009

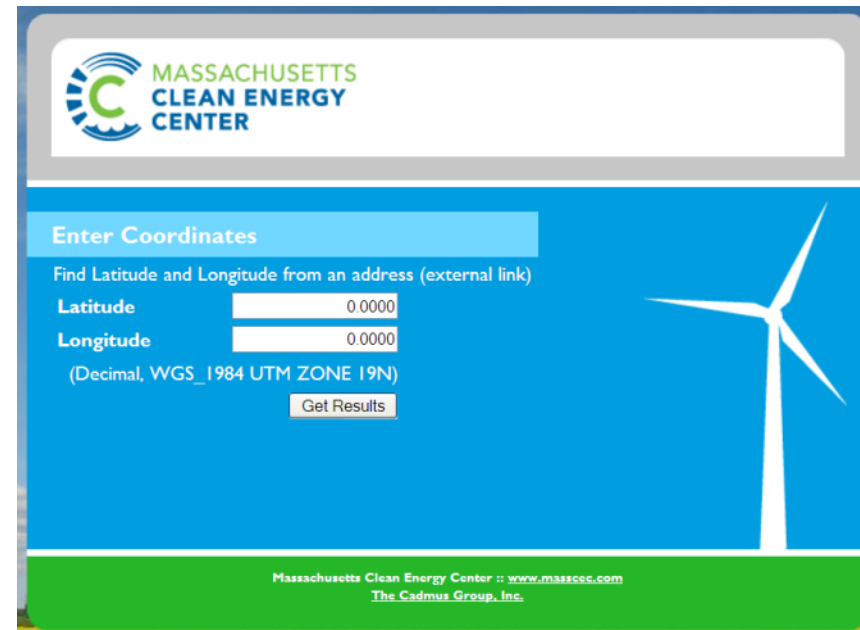
User inputs include:

1. Terrain classification (roughness)
2. Local obstructions
3. Turbine power curve
4. Tower height

Automatically populated fields include:

1. Wind resource (annual mean, wind rose)
2. General loss factors

Accuracy of installer estimates increased from 29% to 81% between 2008 and 2010.



MASSACHUSETTS
CLEAN ENERGY
CENTER

Enter Coordinates

Find Latitude and Longitude from an address (external link)

Latitude

Longitude

(Decimal, WGS_1984 UTM_ZONE 19N)

Get Results

Massachusetts Clean Energy Center :: www.masscec.com
The Cadmus Group, Inc.

Common Siting Mistakes/Challenges

1. Installing towers that are too short for site conditions

- Tree canopy in New England often 60-80 ft
 - 30-50 ft rotor clearance guideline suggests minimum 100-120 ft tower
 - Surface roughness → turbulence, low wind speeds
- Tower heights constrained by economics, permitting/zoning, and local acceptance

2. Installing turbine in wake/shadow of obstructions

- Momentum wake effects downwind of obstacle
 - Distances up to 20 times the height of obstacle
- Candidate locations restricted by available space, property line setbacks, interconnection runs
-

Case Study: Coonamessett Farm

System: Aircon 10 (10 kW, grid-tied)

Tower: 120-ft, ballasted, tilt-down

Operational Range: 2.5 – 32 m/s

Rotor Speed Regulation: Active pitch/yaw

Installation Date: July 2008

Energy Production to Date: 18,773 kWh**



Key Assumptions vs. Measured Values		
	Predicted (source)	Measured
Wind shear power law exponent (between 16.8m and 30.2m)	0.24 (AWSTrueWind) 0.41 (CWEST)	0.36
Annual mean wind speed at hub height (36.6m)	5.5 m/s (AWSTrueWind) 4.6 m/s (CWEST)	4.3 m/s (extrapolated)
Annual Energy Production	15,500 kWh (CWEST)	5,791* kWh

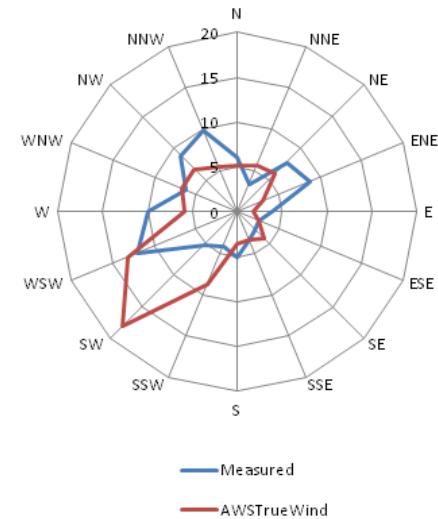
*System experienced significant downtime as a result of controller issues and blade replacement.

**MassCEC On-line Production Tracking System (February 2011)



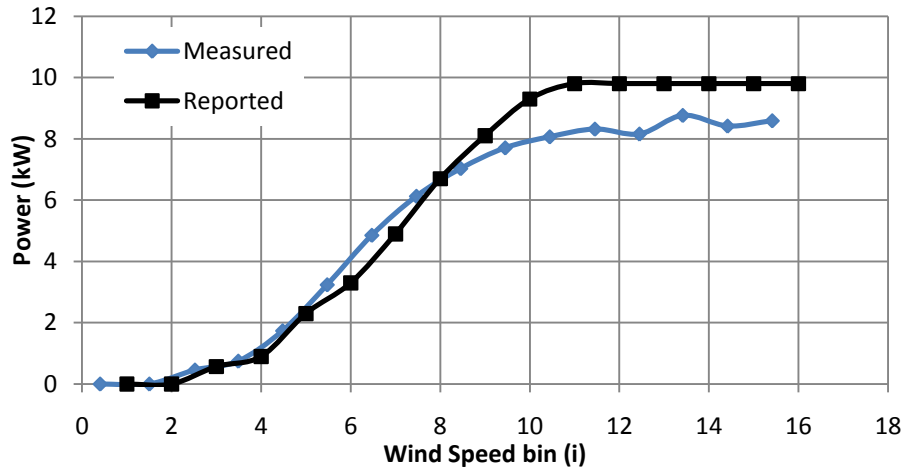
Local Obstructions at Coonamessett Farm

0.3 mean turbulence intensity at 30 meters



Case Study: Coonamessett Farm

Manufacturer-provided and Measured Power Curves
Normalized to Sea Level Air Density (1.225 kg/m³)



Actual vs. Theoretical Performance			
	Theoretical		Actual
Wind Resource Parameters	AWS True Power	Measured*	n/a
Annual Production (kWh)	15,500	11,700	5,791*

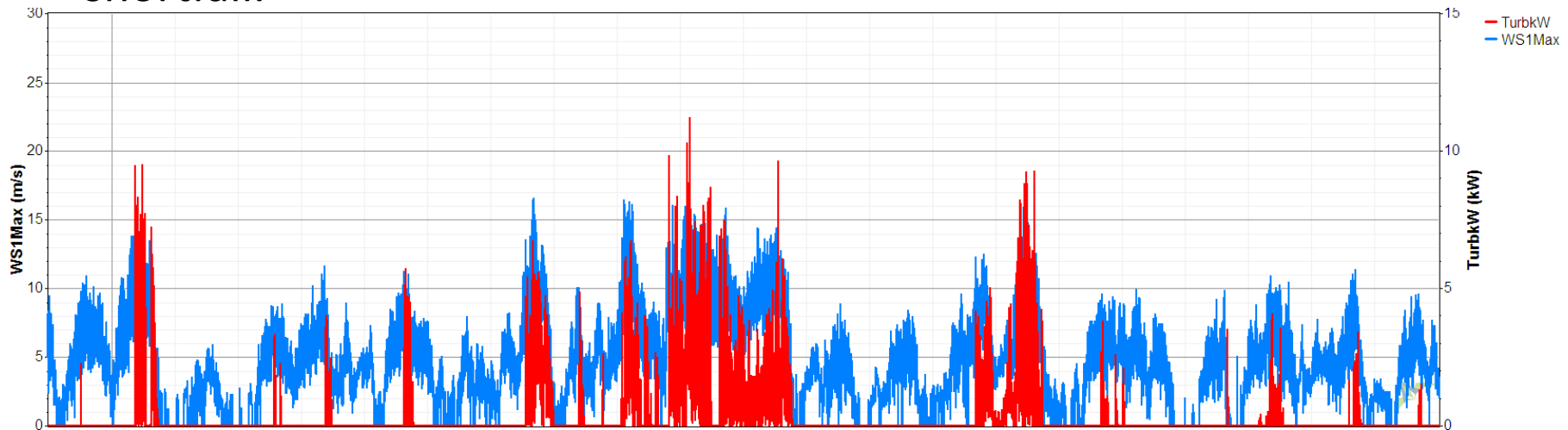
*Measured statistics include wind speed (Weibull distribution), wind shear, wind rose, and power curve.

Combined Uncertainty (90% LOC) for Normalized Power Curve													
Wind Speed Bin (m/s)	4	5	6	7	8	9	10	11	12	13	14	15	16
Combined Uncertainty (Watts)	153	467	807	991	888	718	602	390	333	301	789	618	728

→ System produced less than 50% of expected value!

Small Wind Turbine Performance

Other factors, beyond siting, likely responsible for performance shortfall.



1. Frequency of intervals with zero power suggest that the active control system is shutting down while wind speeds are within operational range.*
2. Active systems may require supervisory control. This suggests that, for small residential systems, passive control may be preferable to smart control logic.

*Maximum measured wind speed at 30 meters shown.

Conclusions and Next Steps

- Small wind is a viable DG option, though far more limited in applicability than solar PV
- Siting and analysis is complex and requires careful evaluation of generation potential and uncertainty
- Costs in MA have dropped since 2004, but less significantly than solar PV
- Installation rates in MA have stabilized in capacity and dropped in number since 2007
- MassCEC continues to support good small wind projects

Next Steps

- Small Wind Progress Report II to be released Summer 2011
- MassCEC taking input of Small Wind Stakeholder Forum 2011