

TALL TOWERS WIND ENERGY MONITORING

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WHAT HAS BEEN LEARNED

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Ithaca, MI, 10 November 2010



Energizing
Michigan

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FCOUS OF PRESENTATION

- ❖ Background of the tall towers wind monitoring project
 - Project team
 - Project objectives
- ❖ Site locations and equipment installed
- ❖ Data collected, reports generated
- ❖ First examination of the results



WIND MONITORING PROJECT TEAM

- ❖ Project is funded by the American Recovery and Reinvestment Act of 2009
 - Competitive grant process
- ❖ Project cooperators
 - Energy Office of the Michigan Department of Energy, Labor and Economic Growth
 - Michigan State University
 - Michigan Public Safety Communications System (MPSCS)
 - Mackinaw Power, LLC (Rich VanderVeen)



PROJECT OBJECTIVES

- ❖ The specific objectives of this project are as follows:
 1. Expand the publicly available information regarding wind energy in Michigan at the higher tower heights
 2. Compare wind energy data collected as part of this project to other wind energy sources



(Project Objectives Continued)

3. Use the collected project data to encourage the development of wind energy in Michigan which will also be a stimulus for job creation, reduce reliance on imported energy and provide for an alternative energy source.
4. Prepare educational materials and hold informational meetings to report results from the project



INSTALLATION SITES

❖ Selection criteria

- Identified good wind area
- A tower was available to install wind monitoring equipment
 - Adequate height
 - Part of system controlled by state
 - Approval of MPSCS

❖ Phase 1 – Prototype System

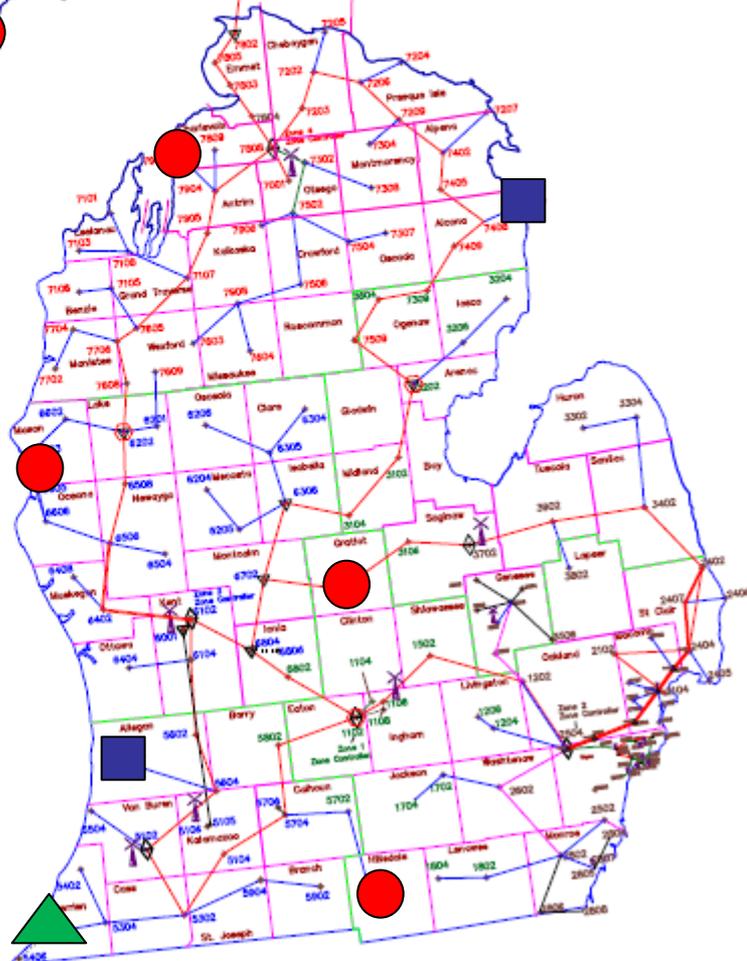
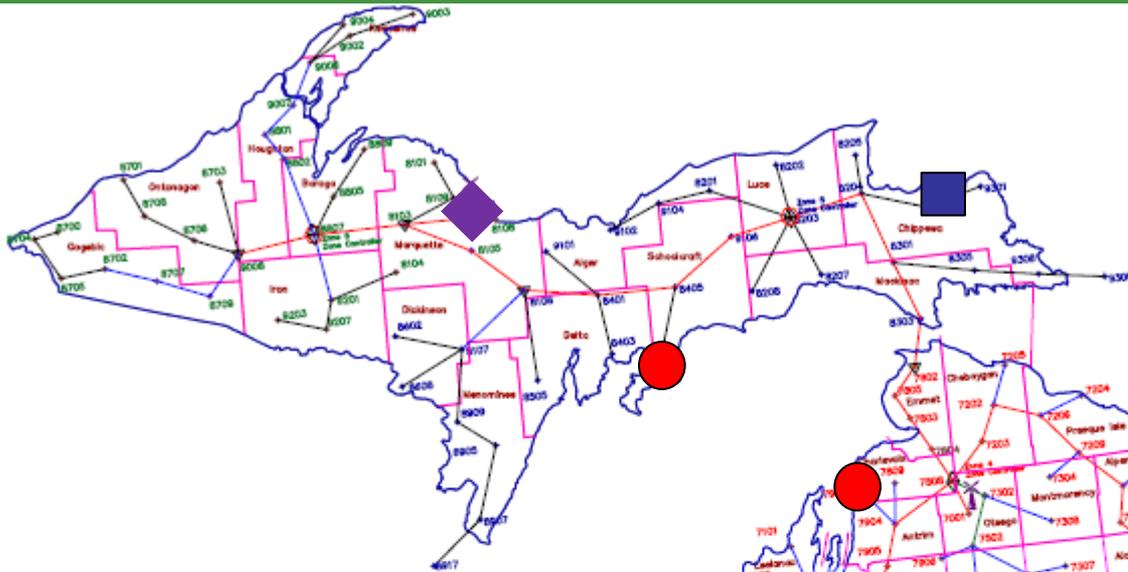
- Berrien County (tower 5404)
- Funded as part of Wisconsin project
- Have been collecting wind data since April 15, 2009.



(Installation Sites Continued)

- ❖ Phase 2 – Current grant selected sites
 - All these sites had equipment installed by mid-May, '10
 - Project defined sites:
 - Gratiot County (Gratiot, Tower 1402)
 - Delta County (Garden, Tower 8407)
 - Antrim County (Atwood, Tower 7901)
 - Mason County (Pentwater, tower 6604)
 - Hillsdale County (Hillsdale, Tower 1902)
 - SWOT Team selected sites:
 - Allegan County (Fennville, Tower 5502)
 - Presque Isle County (Royston, Tower 7207)
 - Chippewa County (Raco, Tower 9302)
 - Private funded tower (installed December 2010)
 - Marquette County (Marquette, Tower 8108)





-  Phase 1
-  Phase 2 – Project Selected
-  Phase 2 – SWOT Selected
-  Phase 2 – Private Funded



EQUIPMENT INSTALLED

<u>Equipment (Sensors)</u>	<u>100-M</u>	<u>80-M</u>	<u>60-M</u>	<u>10-M</u>
Calib. Anemometers	2	2	2	
Wind Direction Vane	1	1		
Temperature Sensor				1
Barometric Pres. Sensor				1

Data logger installed at base of tower

- Has cellular telephone data transfer capability
- Solar cell and battery power source

For three of these towers the project is also collecting wind data at the 120 meter level





DATA MEASURED

- ❖ Data collection period is from equipment installation until June 30, 2012
- ❖ Data sampling process
 - Each instrument is sampled every 2 seconds
 - 10 minutes record is created from the 2-second measurements (mean, max, min & std dev)
 - **Recorded in non-volatile memory**
 - Twice a week data is transmitted by cellular phone/internet to 3 separate computers



REPORTS GENERATED

- ❖ **Standard reports generated by system supplied software from NRG**
 - Wind frequency distribution by time period
 - Wind rose chart by time period
 - Monthly wind average table
 - Monthly wind speed graph
 - Monthly temperature graph
 - Monthly barometric pressure chart
- ❖ **Raw data once cleaned and verified will be placed on-line as comma delimited files**



Site Information:

Project: MSU Tall Towers
Location: Sawyer
Elevation: 670

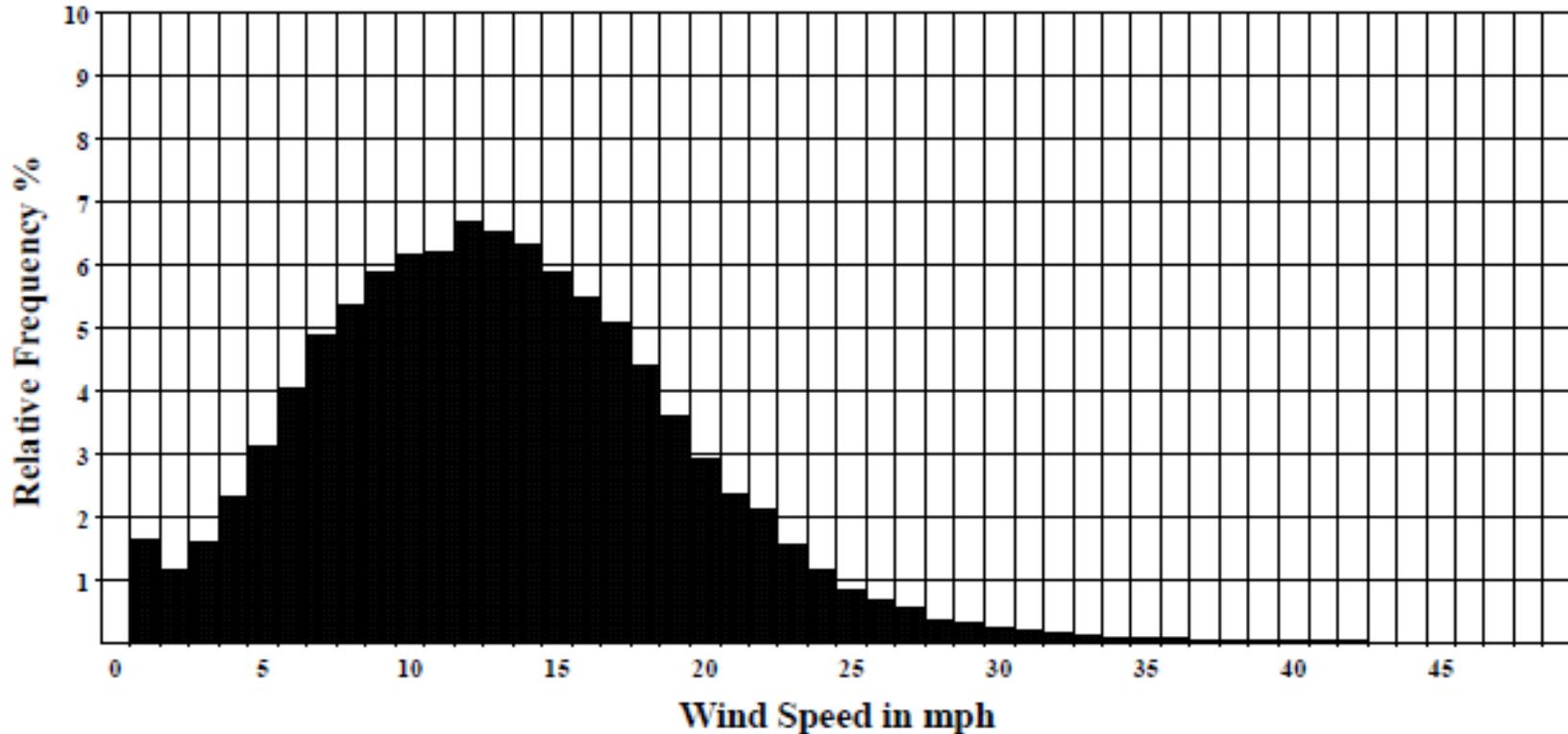
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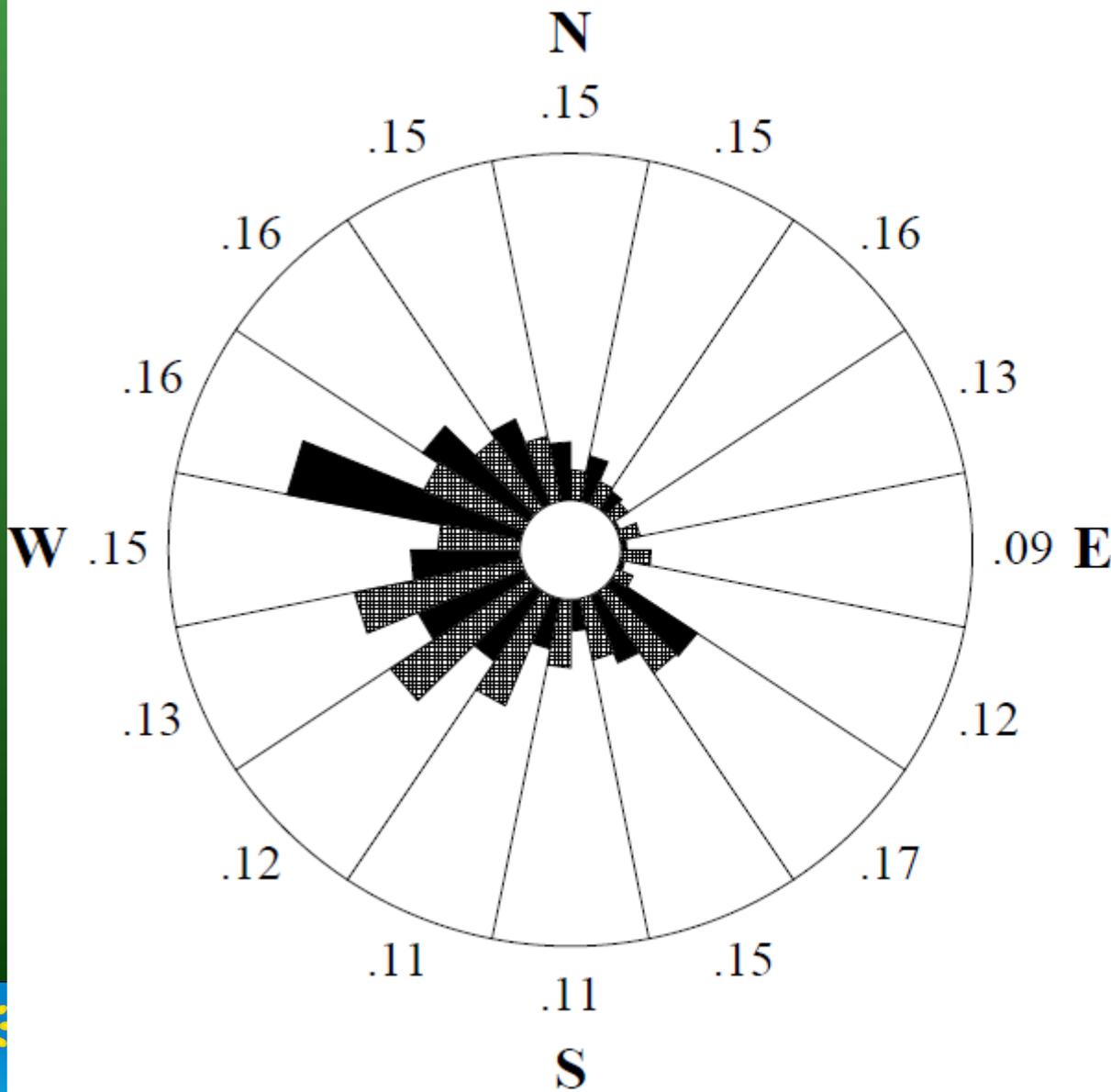
NRG #40 Anem. mph
Height: 328 ft
Serial #: SN:

4/18/2009 to 4/17/2010

Frequency Distribution Ch 1
SITE 1620
Sawyer

Frequency Distribution





December 2009

Wind Rose Ch 1, 7

SITE 1620

Sawyer

Site Information:

Project: MSU Tall Towers

Location: Sawyer

Elevation: 670

Anemometer on channel 1:

NRG #40 Anem. mph

Height: 328 ft

Serial #: SN:

Vane on channel 7:

#200P Wind Vane

Height: 328 ft

Serial #: SN:

Outer Numbers are Average TIIs for speeds greater than 10 mph

Inner Circle = 0%

Outer Circle = 30%

 Percent of Total Wind Energy

 Percent of Total Time



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Site Information:

Project: MSU Tall Towers
Location: Sawyer
Elevation: 670

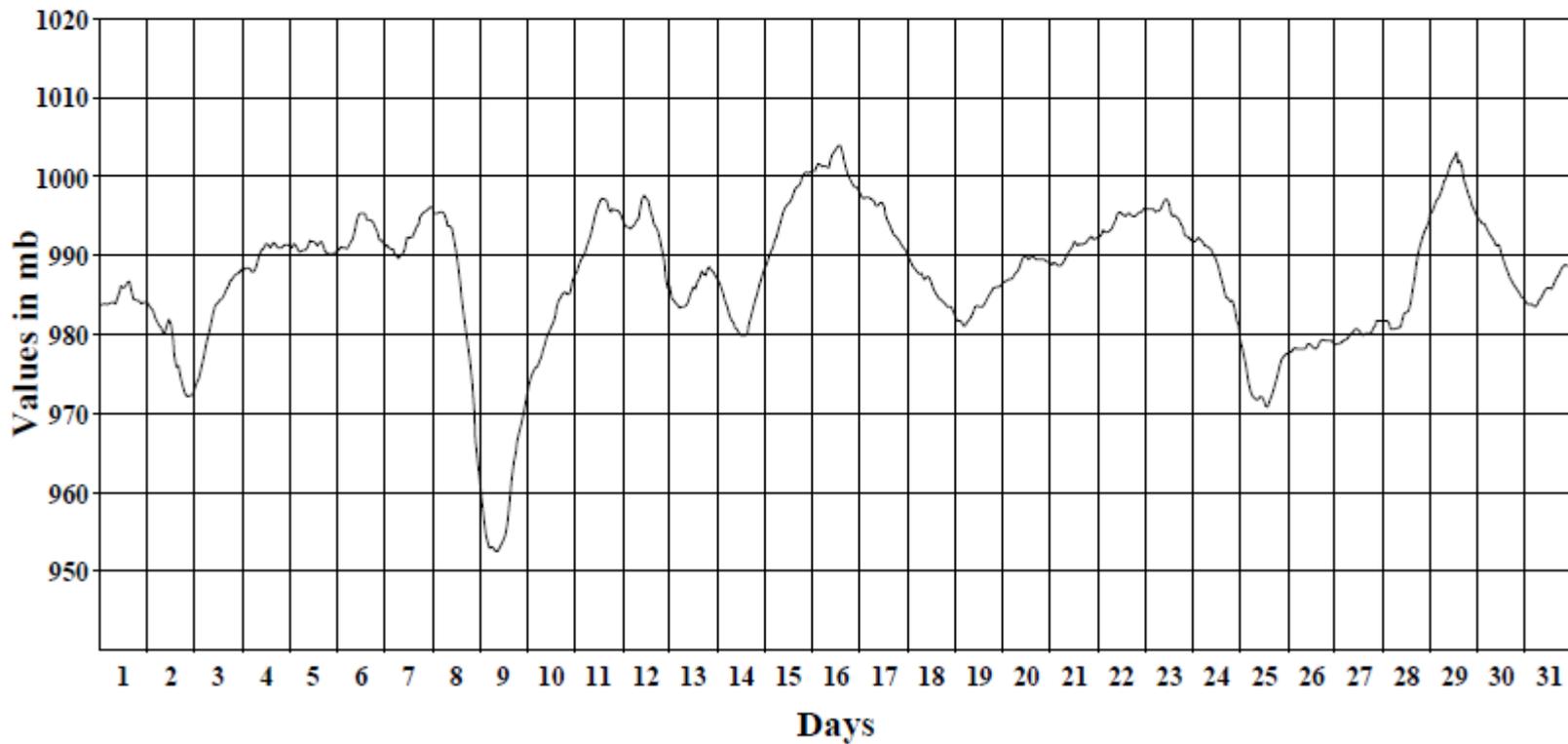
Sensor on channel 10:

BP-20 Barom. mb
Height: 3 m
Serial #: SN:

December 2009

Hourly Averages Graph Ch 10
SITE 1620
Sawyer

Average Hourly Values



Energizing Michigan

RAW DATA FOR DOWNLOAD

```
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One year of data = 2.5 million data elements



Site Information:

Project: MSU Tall Tower Project
Location: Atwood
Elevation: 784

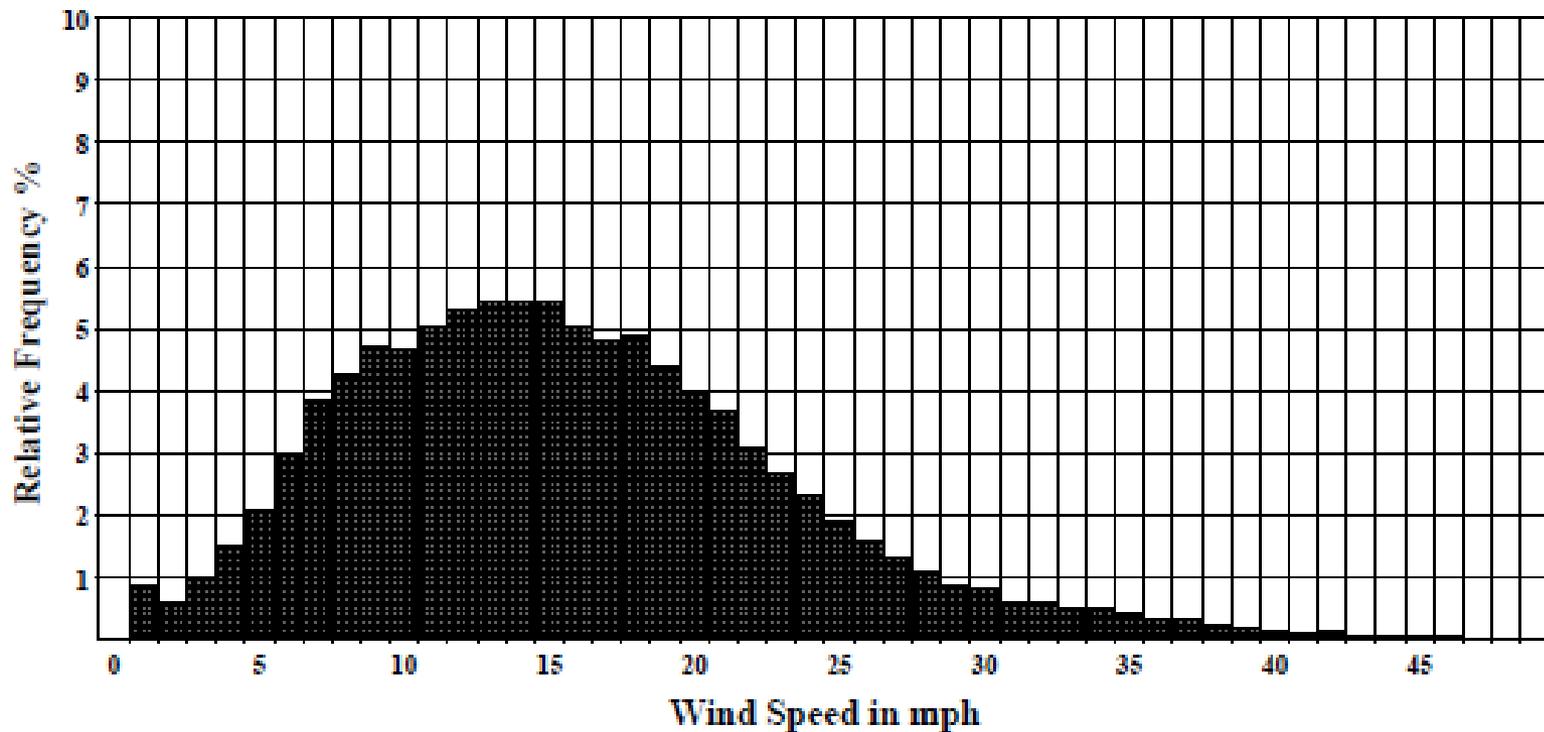
Sensor on channel 1:

NRG #40 Anem. mph
Height: 394 ft
Serial #: SN:

5/18/2010 to 5/17/2011

Frequency Distribution Ch 1
SITE 1690
Atwood

Frequency Distribution



Site Information:

Project: MSU Tall Tower Project
Location: Atwood
Elevation: 784

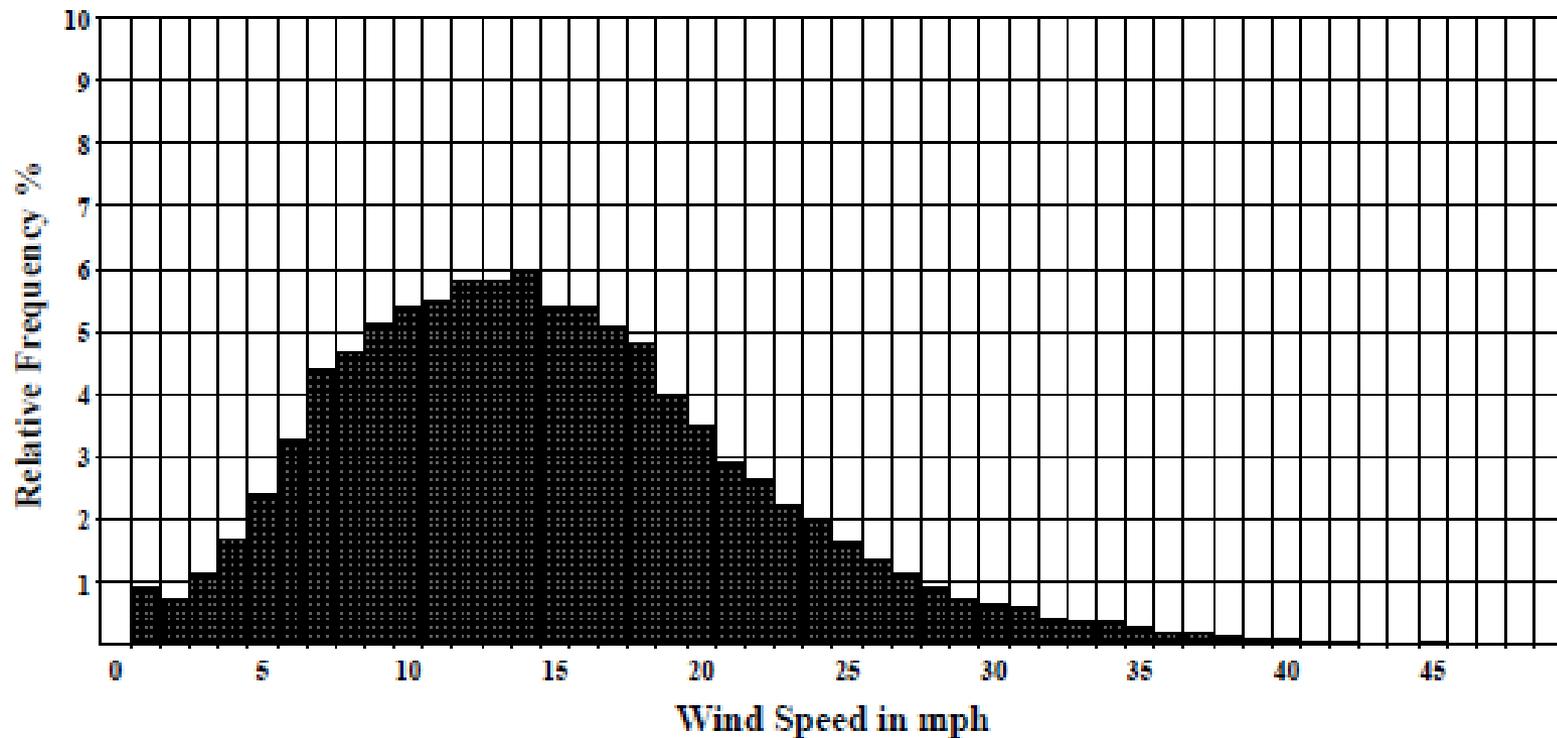
Sensor on channel 3:

NRG #40 Anem. mph
Height: 328 ft
Serial #: SN:

5/18/2010 to 5/17/2011

Frequency Distribution Ch 3
SITE 1690
Atwood

Frequency Distribution



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Site Information:

Project: MSU Tall Tower Project
Location: Atwood
Elevation: 784

Sensor on channel 5:

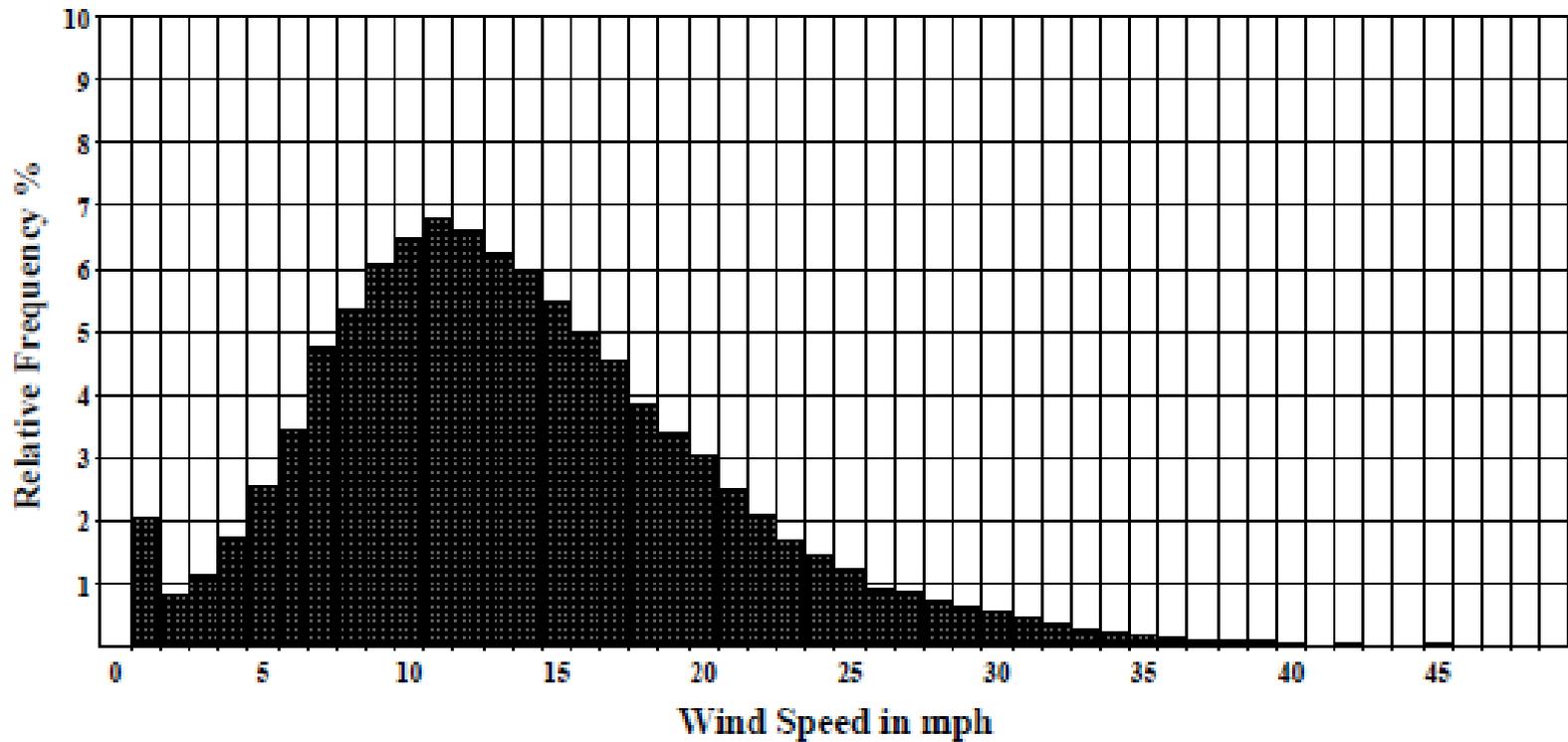
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Height: 263 ft
Serial #: SN:

5/18/2010 to 5/17/2011

Frequency Distribution Ch 5

SITE 1690
Atwood

Frequency Distribution



Site Information:

Project: MSU Tall Tower Project
Location: Atwood
Elevation: 784

Sensor on channel 14:

NRG #40 Anem. mph
Height: 200 ft
Serial #: SN:

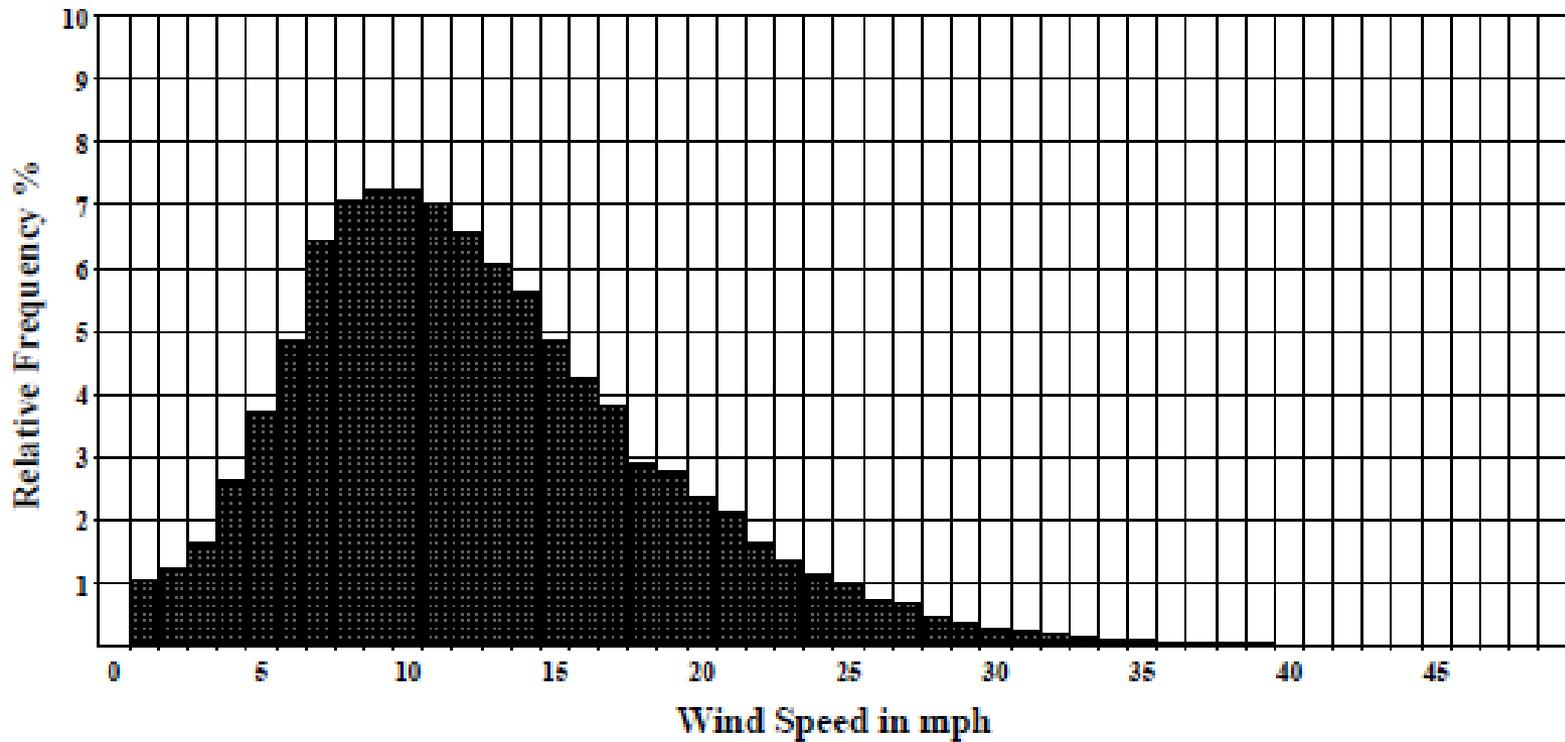
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Frequency Distribution Ch 14

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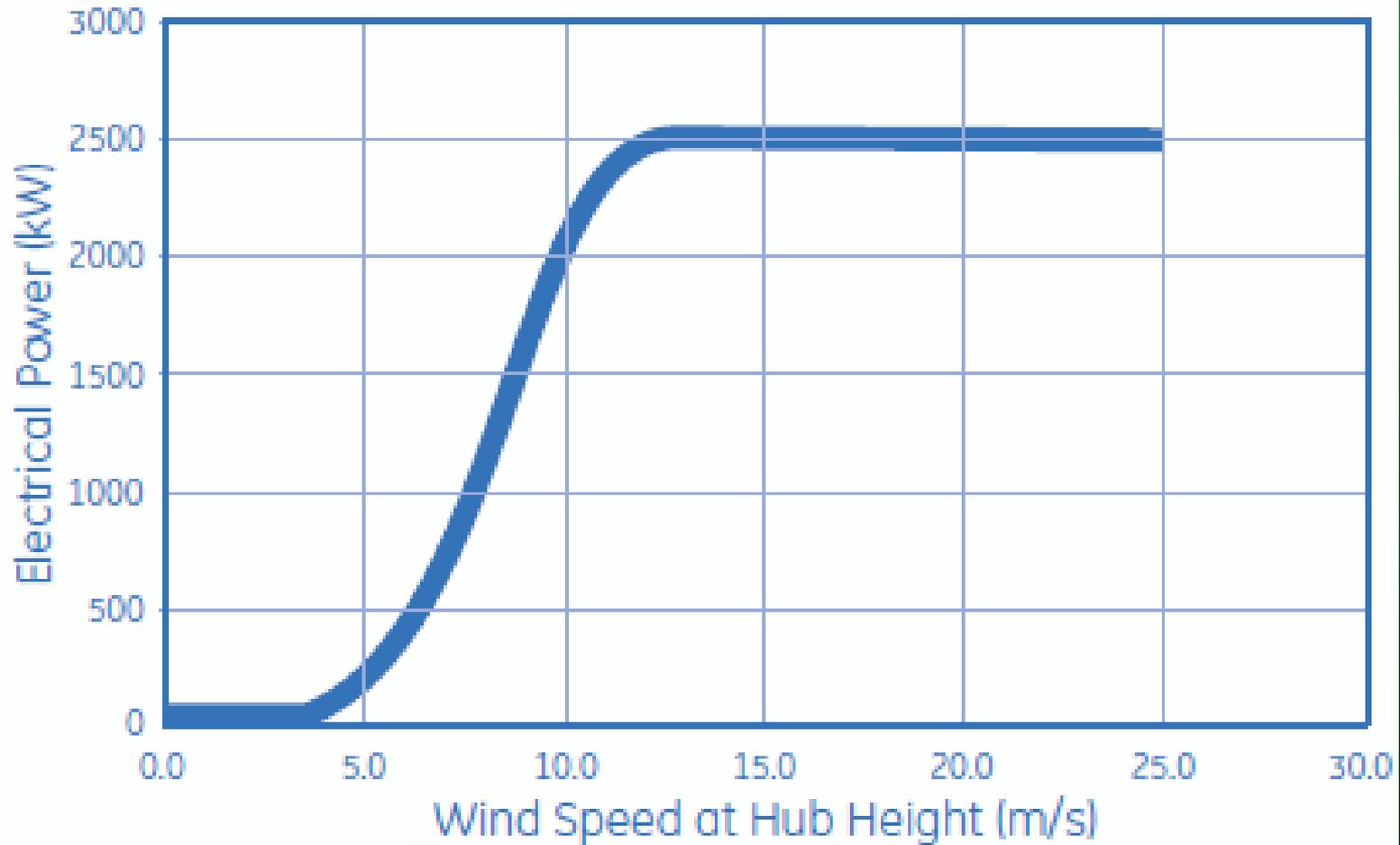
Atwood

Frequency Distribution



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Turbine Power Curve



Height Comparisons, Atwood

Tower Height	80 Meters		120 Meters	
	Percent Frequency	Percent Power	Percent Frequency	Percent Power
Wind Speeds, m/s:				
Below Cut-in	17.9%	0.0%	14.6%	0.0%
Cut-in - 4.9	18.4%	2.4%	14.1%	1.4%
5 -9.9	52.2%	59.2%	52.4%	50.5%
10 -14.9	10.4%	34.4%	16.2%	40.8%
15 -19.9	1.0%	3.7%	2.5%	6.9%
20 -Cut-out	0.1%	0.2%	0.2%	0.4%
	-----	-----	-----	-----
	100.0%	100.0%	100.0%	100.0%
Power, MW/Yr		6,016		7,940



COMPARISON METHOD

- ❖ Draws upon approach used by the NREL and AWS Truewind in developing recent wind maps
 - Uses a NREL developed generic turbine power curve (class 2 turbine)
- ❖ Able to develop gross capacity factors for each site and level
 - Used the 10 minutes records for the entire year
 - **Density adjusted**



Estimated Gross Capacity Factors

120m = 35.2

100m = 32.4

80m = 25.8

60m = 19.3

120m = 36.3

100m = 32.1

80m = 27.5

60m = 21.2

100m = 32.0

80m = 28.9

60m = 21.8

120m = 26.0

100m = 19.0

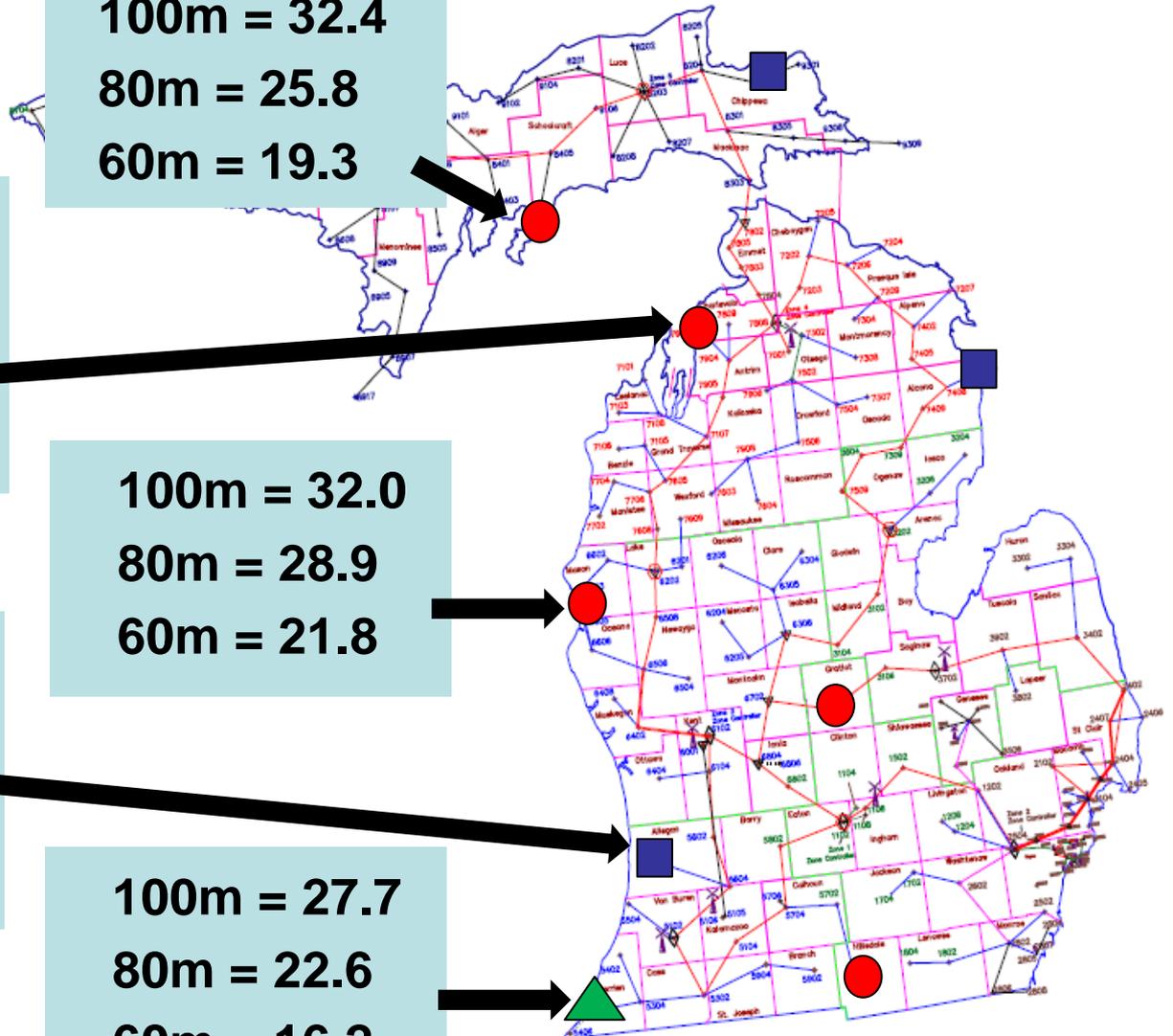
80m = 14.3

60m = 8.8

100m = 27.7

80m = 22.6

60m = 16.2



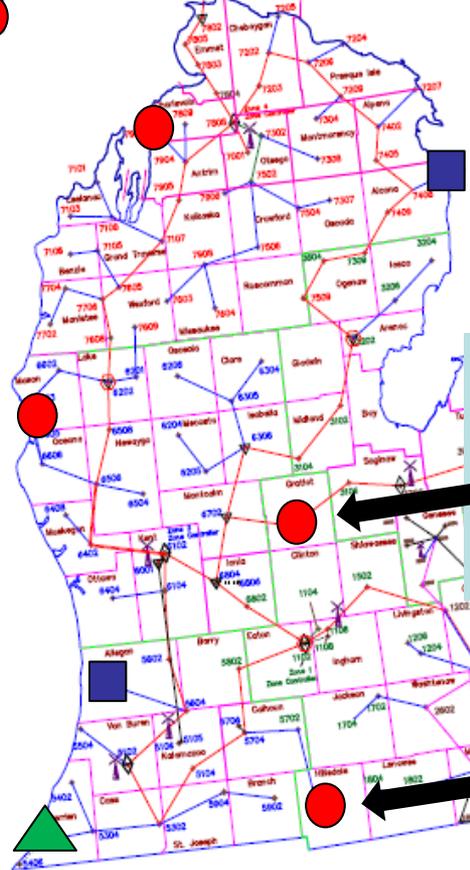
Estimated Gross Capacity Factors



120m = 32.0
 100m = 28.7
 80m = 25.7
 60m = 21.7

100m = 27.0
 80m = 21.2
 60m = 15.3

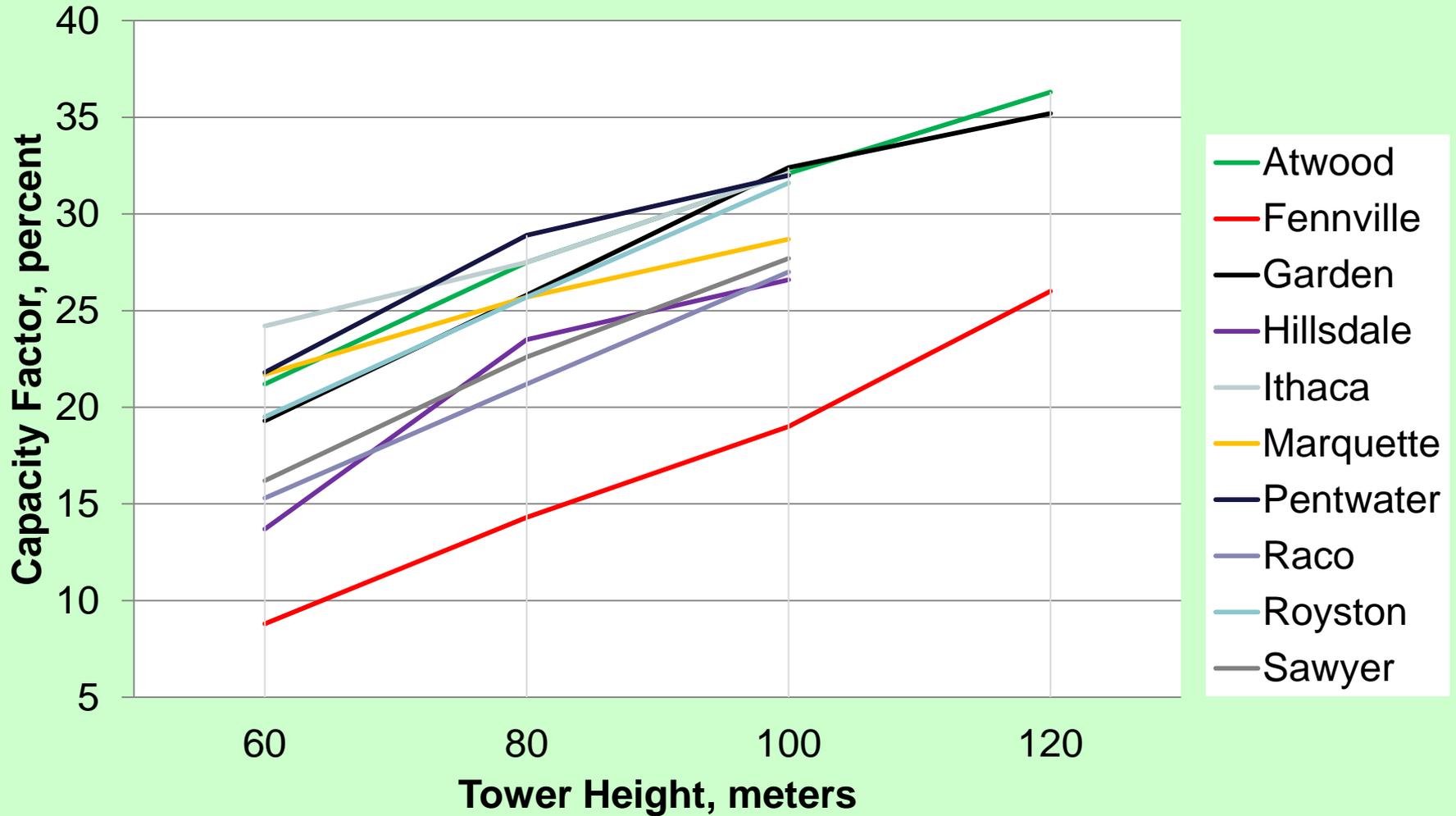
100m = 31.6
 80m = 25.7
 60m = 19.5



100m = 32.1
 80m = 27.5
 60m = 24.2

100m = 32.1
 80m = 27.5
 60m = 24.2

Capacity Factors to Height



Capacity Factors Influenced by Height

Tower Height, m	<u>60</u>	<u>80</u>	<u>100</u>	<u>120</u>
Average	18.17	24.27	28.92	32.50
Percent Change		33.5%	19.1%	16.7%



Yearly Differences in Capacity Factors, Sawyer

Tower Height, m	<u>60</u>	<u>80</u>	<u>100</u>
2009-2010 Capacity Factor	14.5	20.1	25.6
2010-2011 Capacity Factor	16.2	22.6	27.7
Percent Change	11.7%	12.4%	8.2%





<http://www.miwind.info>

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