APPENDIX A
WIND DATA

Appendix A-1
New Ulm Public Utilities
Minnesota Wind Resource Analysis
(July 2007)

WindLogics®

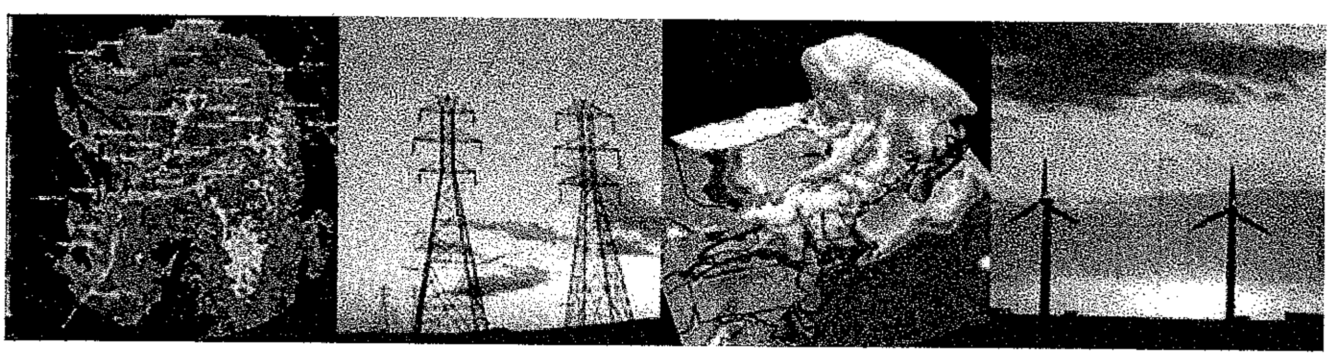
New Ulm Public Utilities

New Ulm, Minnesota

Wind Resource Analysis

July 9, 2007

CONFIDENTIAL MATERIAL ENCLOSED



2007

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NOTES: All data presented in this report are based on the period 1967 – 2006 at 80 m AGL. All Gross Capacity Factor and Gross Energy Production data are based on the Vestas V82 1.65 MW MKII Turbine Power Curve.

New Ulm Public Utilities
New Ulm, Minnesota

Executive Summary

1. INTRODUCTION

1.1 Study Objective
New Ulm Public Utilities engaged WindLogics to analyze the detailed wind characteristics of the New Ulm, Minnesota site. The objective of this study is to provide an analysis of the overall wind regime, including a long-term estimation of the wind resource at 80 m above ground level (AGL), for one virtual tower located on the New Ulm, Minnesota site (see Table 1). The site is located roughly 11 km north of the city of New Ulm in Nicollet County, Minnesota.

Tower	Latitude (WGS 84)	Longitude (WGS 84)	Elevation (in meters)
Tower 1	N 44.40833	W 94.48041	316

Table 1: Virtual Tower Location

VIRTUAL - (BEING ALMOST THE SAME

1.2 Project Description
The WindLogics modeling system was used to gather statistics and information covering the entire site, with a comprehensive analysis reported for one virtual tower located within the bounds of the site. Using data from the WindLogics Weather Data Archive, WindLogics executed a detailed, twelve-month modeling process that was then normalized to reflect long-term values using forty years of additional WindLogics data. Finally, these results were used to generate the conclusions and details in this report.

2. SUMMARY OF RESULTS

VIRTUAL TOWER

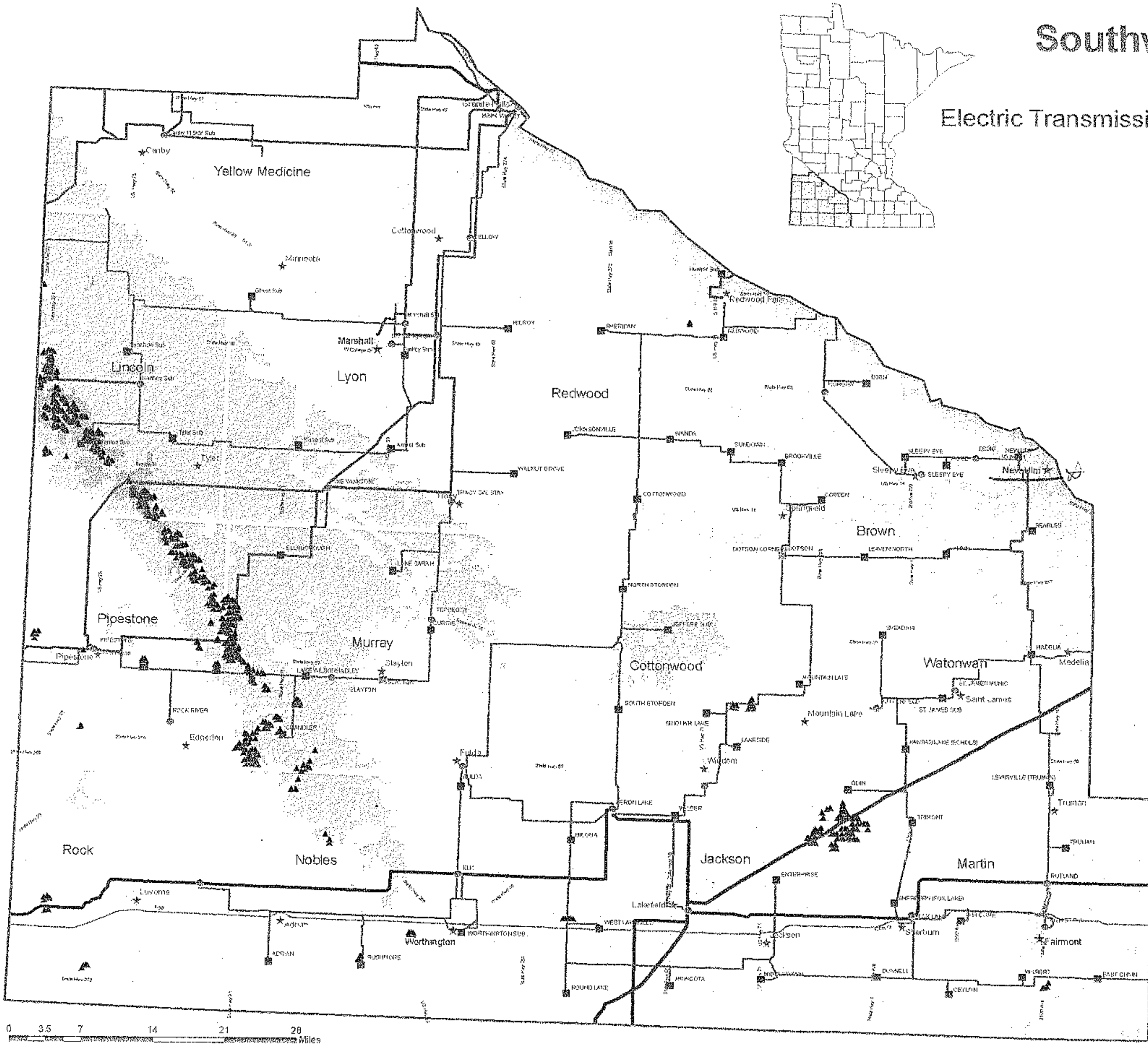
2.1 Annual Wind Speed, Gross Capacity Factor and Gross Energy Production
At the virtual tower location, the annual average wind speed at 80 m AGL is 7.75 m/s, corresponding to an annual gross capacity factor of 44% and an annual gross energy production of 6313 MWh for the Vestas V82 1.65 MW MKII turbine. (SEE NEXT PAGE)

Note: All capacity factor and energy production values in this report are gross values. Net values will depend on losses from project-specific characteristics such as availability, array effects, icing, airfoil soiling, line losses, control losses and other factors.

2.2 Seasonal Characteristics
We typically see decreased wind speeds during the summer months and increased wind speeds during the transitional and cooler months. The average wind speed for the period of October through April is 8.17 m/s, while the May through September time span has an average wind speed of 7.17 m/s. The fastest average monthly wind speed occurs in January with a

Southwest Minnesota Planning Zone

Electric Transmission Lines and Substations



Legend

Gross Turbine Capacity Factor at 80 Meters

- 19% - 32%
- 33% - 35%
- 36% - 38%
- 39% - 40%
- 41% - 43%
- 44% - 46%
- 47% - 49%
- 50% - 51%
- 52% - 53%

▲ Located in SW MN (784)

Substation (with name)

- Distribution (63)
- Other (33)

Line (AC)

- 69 KV or less
- 115 KV
- 161 KV
- 345 KV
- 500 KV
- DC Line

Roadways

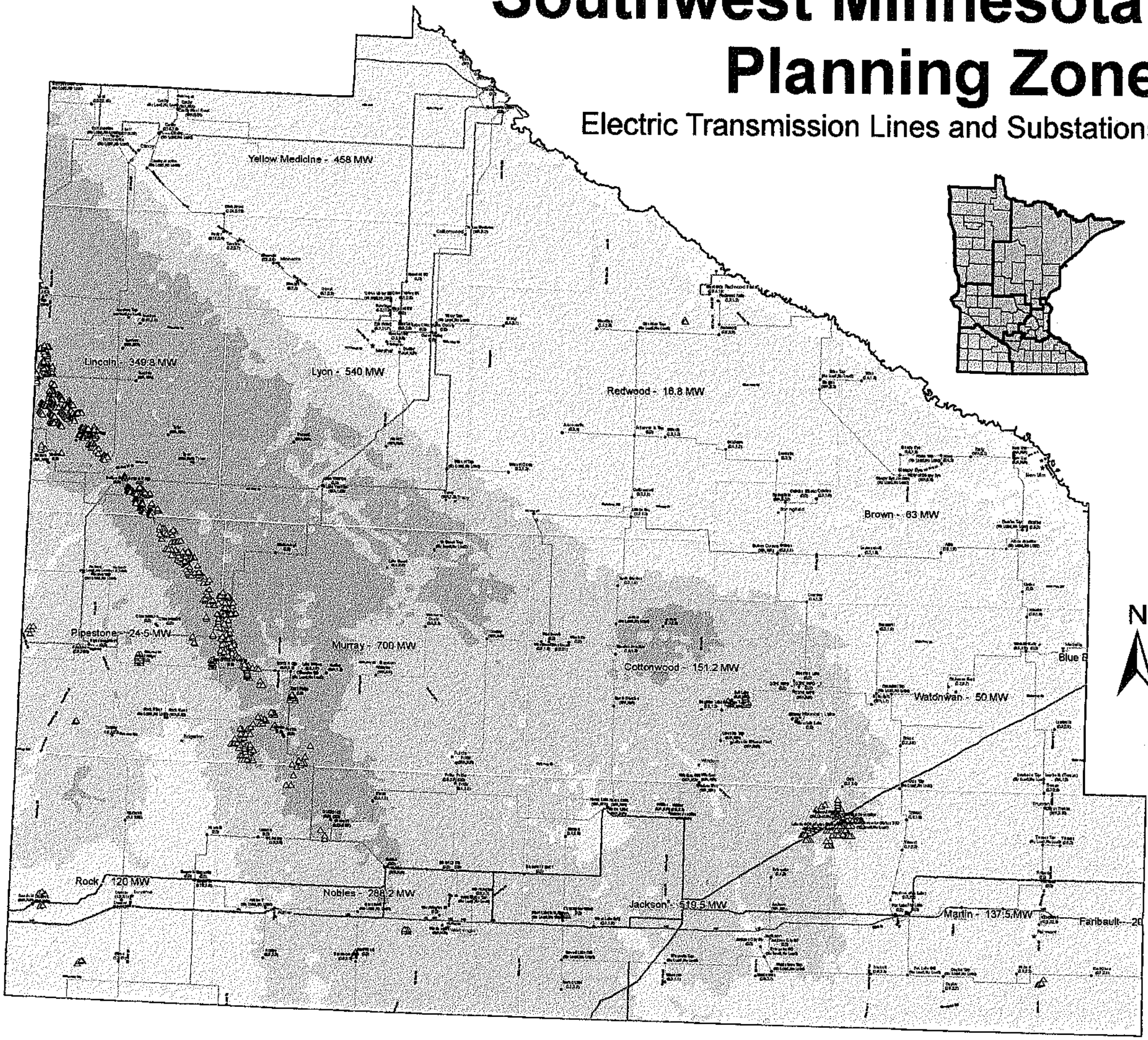
- Interstates
- Other

Cities

- population 10,000-25,000
- population 1,000-10,000

Southwest Minnesota Planning Zone

Electric Transmission Lines and Substations



Legend

Net Turbine Capacity Factor at 80 Meters

- <29%
- 29-31%
- 31-34%
- 34-37%
- 37-39%
- 39-42%
- 42-44%
- 44-47%

Wind Generation

- Wind Turbine Locations

Substations

- Name (Min,Max Historical Load)

Transmission Lines

- 23 kV AC
- 34.5 kV AC
- 41.6 kV AC
- 46 kV AC
- 57 kV AC
- 69 kV AC
- 115 kV AC
- 138 kV AC
- 161 kV AC
- 230 kV AC
- 345 kV AC
- 500 kV AC
- 250 kV DC
- 400 kV DC

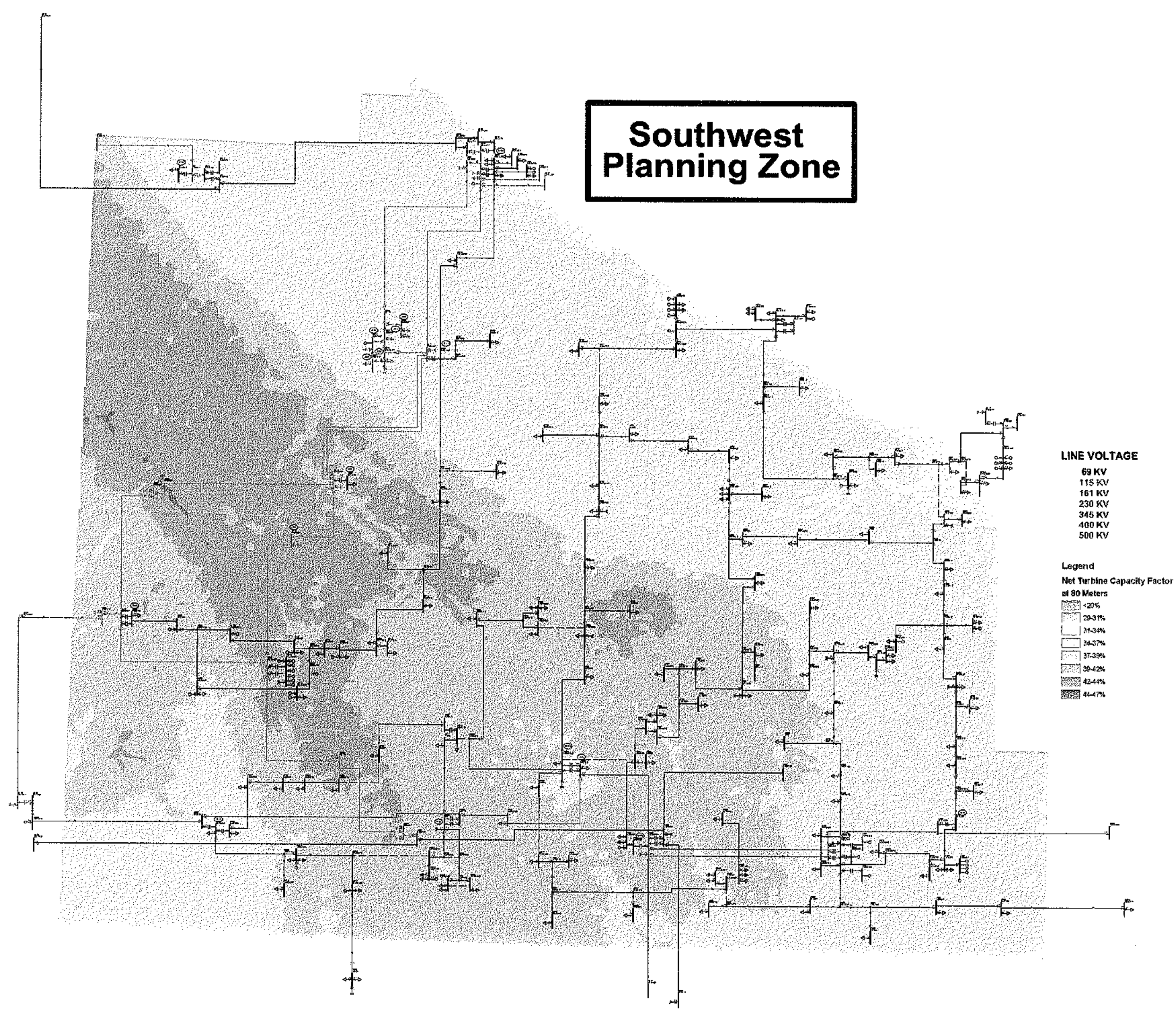
Cities

- Population 25,000+
- Population 10,000 - 25,000
- Cities_Population1000_10000

Roadways

- Interstates
- Highways

Sources:
-Center for Urban and Regional Affairs (CURA)
-Federal Aviation Administration Digital Obstacle Data, aquired from Minnesota Department of Commerce. Xcel file dated 2/12/07.
-Wind Logics 80m Wind Data & Reader, Minnesota Department of Commerce, 11/2005.
-MISO Generation Interconnection Queue, 3/17/2008.


Southwest
Planning Zone
LINE VOLTAGE
69 KV
115 KV
161 KV
230 KV
345 KV
400 KV
500 KV
Legend
Net Turbine Capacity Factor
at 80 Meters

value of 8.38 m/s, corresponding to a gross capacity factor of 50% (611 MWh) for the Vestas V82 1.65 MW MKII turbine. July has the slowest average monthly wind speed with a value of 6.62 m/s, corresponding to a gross capacity factor of 30% (367 MWh) for the Vestas V82 1.65 MW MKII turbine.

Note: The highest (lowest) average wind speed months may not be the highest (lowest) energy production months because energy production depends upon the wind speed distribution and hourly air density, not just the average monthly wind speed.

2.3 Long-Term Normalization Method

The output from the WindLogics modeling process was normalized to represent the long-term wind resource and was processed using the WindLogics Enhanced Measure Correlate Predict (E-MCP or Enhanced MCP) method to compute short-term and normalized long-term datasets. For more information, see Section 3.7.

2.4 Meteorological Overview

The meteorology of the Upper Midwest is dominated by the location and strength of the jet stream and related tracks of synoptic-scale weather systems (i.e., low and high pressure systems). During the winter and transitional seasons, the New Ulm, Minnesota site is influenced by transient and developing synoptic-scale weather systems associated with the cool/cold season jet stream position. These systems establish the pressure gradients that drive low-level winds. In the summer, the jet stream weakens and moves north, resulting in generally weaker synoptic systems and weaker winds.

3. METHODOLOGY AND DATA

3.1 Methodology Overview

The WindLogics Weather Data archive and modeling system were used to model the wind activity of the site and generate statistics of the study region. The data archives were used as input to the MM5 mesoscale modeling system with an inner grid resolution of 3 km (see Appendix A, Page 1). The output from the MM5 modeling was then used as input to the detailed windfield modeling system consisting of an outer grid with a resolution of 1 km and an inner grid with a resolution of 50 m (see Appendix A, Pages 2 and 3).

Hourly time series were run for the entire period and statistics were accumulated on a monthly and annual basis. The results were then normalized to long-term climatic means using 40 years of data from the WindLogics NCEP/NCAR Reanalysis data archive (see Section 3.7 for the long-term normalization description).

3.2 Turbine Model & Power Curve

The gross energy production results were calculated for the Vestas V82 1.65 MW MKII turbine. The WindLogics modeling system calculates energy production using time-dependent air density and hourly wind speed values produced from the models.
Please note also:

1) The power curve used in this study was created from documentation supplied by Vestas (See Appendix B).

2) The standard Vestas power curve used in the study was modified on an hour-by-hour basis according to the air density values.
3) The WindLogics modeling process used the standard Vestas power curve at 1.225 kg/m^3. Energy production was calculated using the actual air density (from the modeling process) at the site/point location for each hour in order to adjust the wind speed that was applied to the power curve for that hour.
4) The formula that was used to adjust the wind speed is: WS*(AD/1.225)$^{(1/3)}$, where AD is the modeled air density and WS is the model estimated wind speed at that hour.

3.3 Topography Data
Fifty-meter resolution topography data acquired from USGS (United States Geological Survey) was used as input to the WindLogics modeling system along with USGS land-use and roughness information.

3.4 Vegetative and Land Cover Data
1) WindLogics took into account several sources (satellite imagery, USGS land cover information, etc.) to assess the overall land cover of the region.
2) The land cover over the area is mostly farmland and is void of significant tree coverage. Given this land cover, no displacement height was used.

3.5 WindLogics Archive Data for Detailed Analysis
The continuous modeling process used data from the WindLogics North American Archive, consisting of hour-by-hour assimilated weather data at a 20-km horizontal spacing between grid point columns. This data is a physics-based assimilation from many sources, both direct measurement and remote sensing (e.g., satellite) sources, and was initially created by The National Centers for Environmental Prediction (NCEP) as a starting point for their Rapid Update Cycle forecast model. It is a complete, physically-consistent matrix of the atmospheric conditions and includes wind, temperature, pressure and many other weather variables. WindLogics has collected and organized this data and now has more than six years of this North American data online.

3.6 WindLogics Weather Archive for Long-Term Normalization
WindLogics also has an online archive of more than 55 years of worldwide weather data used for normalizing the results of the mesoscale modeling to reflect long-term values and for studying the inter-annual variation of the wind resource. The National Centers for Environmental Prediction (NCEP) and National Center for Atmospheric Research (NCAR) have cooperated in this "Global Reanalysis" project to produce a retroactive record of atmospheric weather data fields in support of the needs of the research and climate monitoring communities. This effort involved the recovery of land surface, ship, rawinsonde, aircraft, satellite and other data; ensuring strict quality control of all data; and assimilating all data with a data assimilation system that is kept unchanged over the complete period. Most data fields are saved four times per day (every 6 hours) and the horizontal resolution is approximately 210 km. WindLogics has developed special technology to maintain this complete dataset online and obtain wind data from the archive at turbine hub height over the entire planet.

3.7 WindLogics Enhanced MCP Normalization Process Overview
The WindLogics Enhanced Measure Correlate Predict (E-MCP or Enhanced MCP) method

uses an advanced computational learning system combined with simultaneous use of multiple long-term data points. Computational learning systems are a type of "artificial intelligence" that is concerned with detection and use of the complex patterns and relationships in data. The patterns may be extremely complex and non-intuitive, and can involve complicated multi-point or multi-value non-linear relationships.

The WindLogics computational learning system approach involves using a large number of cases for which we have both a set of known "hypothesis" variables and a known "target" variable. This information is used to train the system to estimate the target quantity from the hypothesis variables. In the training process, patterns of complex relationships between the hypothesis and target variables are detected. This training information is then used to estimate the target variable for other timeframes - timeframes for which we have the hypothesis variables but not the target variable. For this study, data for the hypothesis variables came from WindLogics NCEP/NCAR Reanalysis archive. The target variable was the model-based wind speed at a hub height of 80 m AGL for the Tower 1 location (See Table 1).

To estimate the error in the E-MCP based prediction, a round-robin approach was used in which each month was predicted without using that month's data in training. In other words, each of the 12 months was estimated using the other 11 months of training data. This required a separate training and estimation process for each of the months, plus the final process that used training data from all months to estimate the long-term time series.

The average monthly wind speed error for this E-MCP training was 4.73% and the correlation to model-based wind speed values had a coefficient of determination (R^2) of 0.78. The 12-month overall bias was 0.32%. The quality of this E-MCP training is illustrated by the histogram in Figure 1. Figure 1 shows how well the E-MCP training captured the distribution over the full range of wind speed values. Prediction of the wind speeds from the E-MCP method are shown, along with the actual data used from the short-term training period.

SECTION 1A

NORMALIZED MONTHLY AND ANNUAL AVERAGE WIND SPEED VALUES

Mean quantities normalized to long-term average.
Data distributions representative of modeled year.

WindLogics Inc.
1217 Bandana Blvd. N., St. Paul, MN 55108 Tel: 651.556-4200 Fax: 651.556-4210
www.windlogics.com

2007

VIRTUAL

Normalized Monthly and Annual Wind Speed Averages (in m/s)
New Ulm, Minnesota - Tower 1 - 80 m

Month	m/s
January	8.38
February	8.01
March	8.09
April	8.21
May	7.68
June	7.22
July	6.62
August	6.76
September	7.56
October	8.18
November	8.14
December	8.18
Annual Average	7.75

??

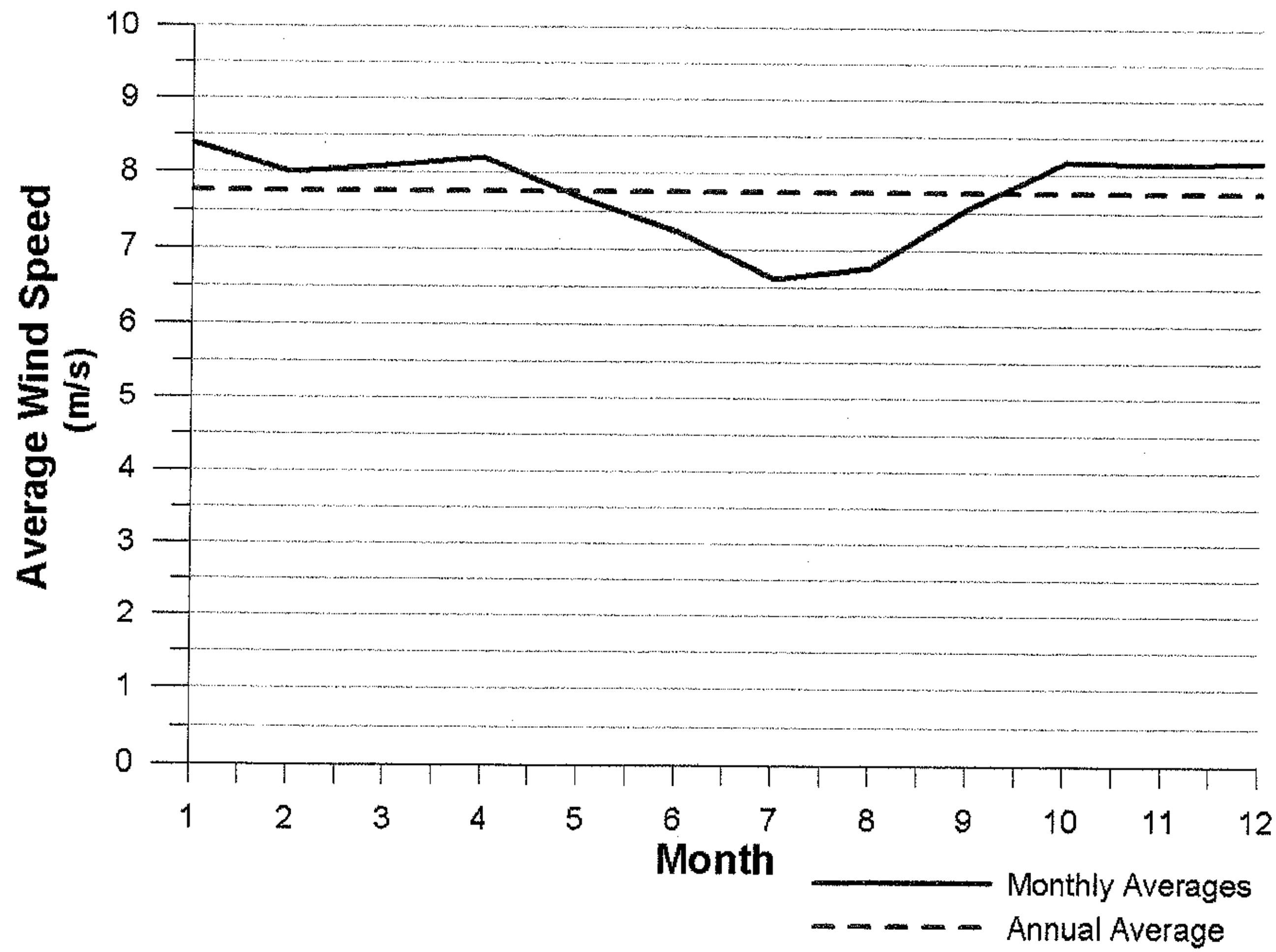
TOO HIGH COMPARED TO NOV 30 MINNESOTA 2006 INTEGRATION STUDY (3 yr NORMALIZED WIND SPEED MAPS) Pg 56 ; 60

IF THIS IS OFF - GROSS CAPACITY WILL BE OFF TOO!

THIS REPORT DONE ABOUT 8 MONTHS LATER! 2007

Mean quantities normalized to long-term average.
Data distributions representative of modeled year.

Normalized Monthly and Annual Wind Speed Averages (in m/s)
New Ulm, Minnesota - Tower 1 - 80 m



Mean quantities normalized to long-term average.
Data distributions representative of modeled year.

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2007

SECTION 1B

NORMALIZED MONTHLY AND ANNUAL GROSS ENERGY PRODUCTION AND CAPACITY FACTOR VALUES

Mean quantities normalized to long-term average.
Data distributions representative of modeled year.

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2007

Normalized Monthly and Annual Gross Energy Production and Capacity Factor
New Ulm, Minnesota - Tower 1 - 80 m

Vestas V82 1.65 MW MKII		
Month	EP (MWh/mo)	CF
January	611	50%
February	552	50%
March	559	46%
April	574	48%
May	535	44%
June	452	38%
July	367	30%
August	419	34%
September	459	39%
October	564	46%
November	604	51%
December	617	50%
	EP (MWh/yr)	CF
Annual	6313	44%

BASED ON 7.75 WIND SPEED AVERAGE

Mean quantities normalized to long-term average.
Data distributions representative of modeled year.

2007

Table of Prediction Intervals on Annual Gross Energy Production
(Based on Annual Averages)
New Ulm, Minnesota - Tower 1 - 80 m

	P50	P75	P90	P95	P99
Energy (MWh)	6313	6118	5939	5830	5617
Capacity Factor	43.68%	42.32%	41.09%	40.33%	38.86%

Number of Years	40
Mean	6313
Standard Deviation	283

Mean quantities normalized to long-term average.
Vestas V82 1.65 MW MKII Turbine Power Curve

L007

WindLogics®

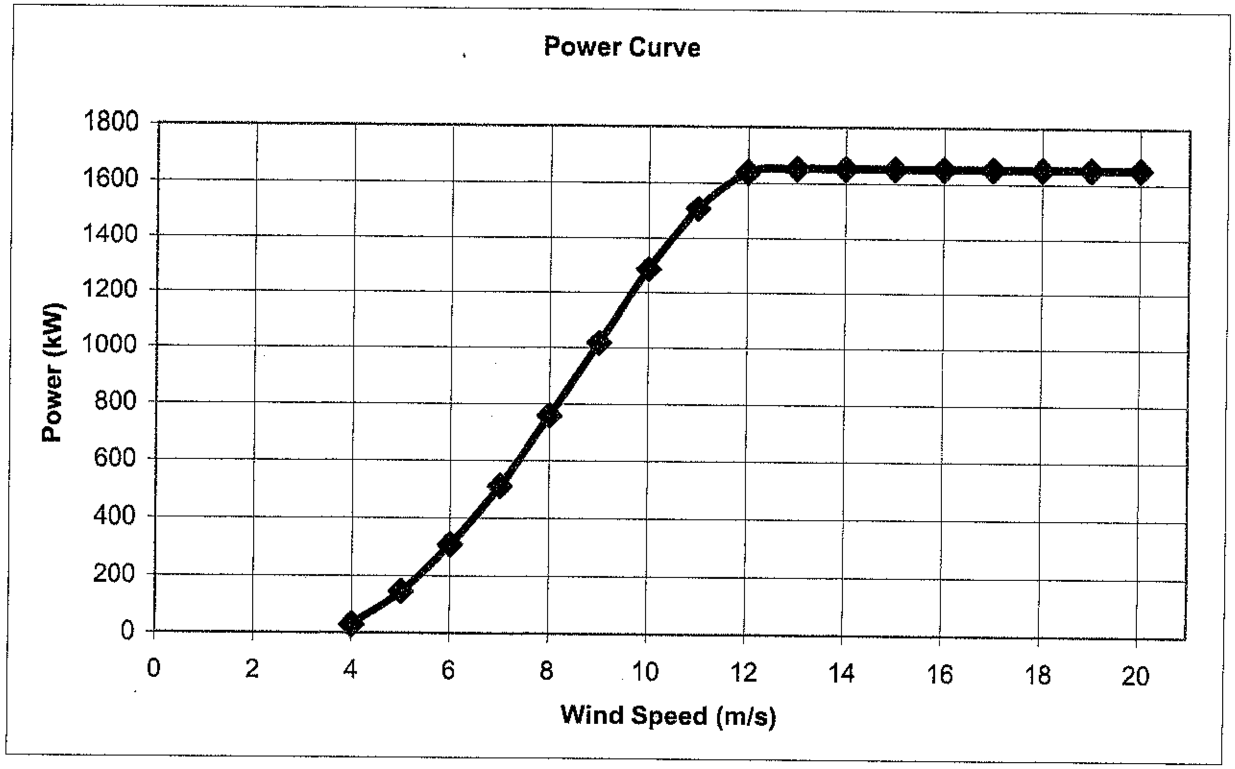
Vestas V82 1.65 MW MKII

Wind Speed (m/s)	Power (kW)
3	0
4	28
5	144
6	309
7	511
8	758
9	1017
10	1285
11	1504
12	1637
13	1650
14	1650
15	1650
16	1650
17	1650
18	1650
19	1650
20	1650
> 20	0

Standard Operational Data	
Cut in Wind Speed	3.5 m/s
Cut out Wind Speed	20 m/s
Air Density	1.225 kg/m^3
Capacity	1650 kW
Rotor Diameter	82 m

The WindLogics modeling process uses the standard power curve at 1.225 kg/m^3. The modeled air density (for each hour and site/point location) is used to adjust the wind speed that is applied to the power curve for that hour.

The formula that is used to adjust the wind speed is:
Air Density Adjusted Wind Speed = WS * (AD/1.225) $^{(1/3)}$
Where AD is the modeled Air Density and WS is the model estimated Wind Speed at that hour



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Appendix A-2
Wind Summary Data from the NUPUC On-Site Meteorological Tower
(December 2008-February 2009)

3 MONTHS (WINTER)
(DATA)
3 pages - TOTAL

APPENDIX A-4 December 2008 Wind Summary

Site Information:
Project: A3-1
Location:
Elevation: 307 m

Sensor Information:
1 NRG #40 Anem, m/s
2 NRG #40 Anem, m/s
3 NRG #40 Anem, m/s
4 NRG #40 Anem, m/s
5 NRG #40 Anem, m/s
6 NRG #40 Anem, m/s
7 #200P Wind Vane
8 #200P Wind Vane
9 No Sensor
10 No Sensor
11 NRG 110S Temp, C
12 iPack Voltmeter

December 2008
Summary Report
SITE 5643
New Ulm Wind Farm

Channel	1	2	3	4	5	6	7	8			11	12
Height	58	58	45	45	32	32					2	
Units	m/s	m/s	m/s	m/s	m/s	m/s	deg	deg			C	volts
Intervals with Valid Data	4464	4464	4464	4464	4464	4464	4464	4464			4464	4464
Average Filtered Data	7.79	7.93	7.29	7.59	7.01	7	265.24	256.74			158.45	13.72
Average for All Data	7.79	7.93	7.29	7.59	7.01	7	265.24	256.74			158.45	13.72
Min Interval Average	0.3	0.4	0.4	0.4	0.3	0.4					143.2	12.8
Date of Min Interval	12/07/2008	12/07/2008	12/07/2008	12/07/2008	12/07/2008	12/07/2008					12/22/2008	12/14/2008
Time of Min Interval	3:20:00 AM	3:20:00 AM	3:20:00 AM	3:20:00 AM	3:20:00 AM	3:10:00 AM					6:30:00 AM	9:30:00 PM
Max Interval Average	19.6	20	18.9	19.2	18.1	18.4					176.1	15.1
Date of Max Interval	12/29/2008	12/29/2008	12/29/2008	12/29/2008	12/29/2008	12/29/2008					12/02/2008	12/15/2008
Time of Max Interval	7:30:00 AM	7:30:00 AM	7:30:00 AM	7:30:00 AM	7:30:00 AM	7:30:00 AM					3:10:00 PM	8:30:00 AM
Average Interval SD	0.7	0.68	0.71	0.69	0.71	0.71	3.69	4.11			0.04	0.01
Min Sample	0.3	0.4	0.4	0.4	0.3	0.4					142.9	12.5
Date of Min Sample	12/07/2008	12/07/2008	12/07/2008	12/07/2008	12/07/2008	12/07/2008					12/22/2008	12/14/2008
Time of Min Sample	2:20:00 AM	2:20:00 AM	2:20:00 AM	2:20:00 AM	12:20:00 AM	2:20:00 AM					6:30:00 AM	9:30:00 PM
Max Sample	24.6	25	23.9	23.9	23.9	23.5					176.2	15.2
Date of Max Sample	12/29/2008	12/29/2008	12/29/2008	12/29/2008	12/29/2008	12/29/2008					12/02/2008	12/22/2008
Time of Max Sample	7:30:00 AM	7:30:00 AM	7:30:00 AM	7:30:00 AM	7:30:00 AM	7:30:00 AM					3:10:00 PM	8:00:00 AM
Average Interval TI	0.09	0.09	0.1	0.09	0.11	0.11						
Wind Speed Direction							W	W				

APPENDIX A-4 January 2009 Wind Summary

Site Information:
Project: A3-1
Location:
Elevation: 307 m

Sensor Information:
1 NRG #40 Anem, m/s
2 NRG #40 Anem, m/s
3 NRG #40 Anem, m/s
4 NRG #40 Anem, m/s
5 NRG #40 Anem, m/s
6 NRG #40 Anem, m/s
7 #200P Wind Vane
8 #200P Wind Vane
9 No Sensor
10 No Sensor
11 NRG 110S Temp, C
12 iPack Voltmeter

January 2009
Summary Report
SITE 5643
New Ulm Wind Farm

Channel	1	2	3	4	5	6	7	8			11	12
Height	58	58	45	45	32	32					2	
Units	m/s	m/s	m/s	m/s	m/s	m/s	deg	deg			C	volts
Intervals with Valid Data	4464	4464	4464	4464	4464	4464	4464	4464			4464	4464
Average Filtered Data	7.23	7.3	6.8	6.93	6.45	6.48	286.73	279.28			156.75	13.83
Average for All Data	7.23	7.3	6.8	6.93	6.45	6.48	286.73	279.28			156.75	13.83
Min Interval Average	0.3	0.4	0.4	0.4	0.3	0.4					137.9	12.7
Date of Min Interval	01/22/2009	01/22/2009	01/22/2009	01/22/2009	01/22/2009	01/22/2009					01/15/2009	01/14/2009
Time of Min Interval	2:20:00 PM	2:20:00 PM	11:00:00 AM	11:00:00 AM	11:10:00 AM	11:00:00 AM					7:30:00 AM	10:00:00 PM
Max Interval Average	18.9	19.5	18.3	18.6	17.4	17.9					176.2	15.3
Date of Max Interval	01/17/2009	01/17/2009	01/17/2009	01/17/2009	01/17/2009	01/17/2009					01/31/2009	01/15/2009
Time of Max Interval	2:30:00 PM	2:30:00 PM	2:30:00 PM	2:30:00 PM	2:30:00 PM	2:30:00 PM					2:20:00 PM	8:10:00 AM
Average Interval SD	0.6	0.6	0.61	0.61	0.62	0.62	4.8	5.59			0.04	0.01
Min Sample	0.3	0.4	0.4	0.4	0.3	0.4					137.7	12.3
Date of Min Sample	01/02/2009	01/02/2009	01/02/2009	01/02/2009	01/02/2009	01/02/2009					01/15/2009	01/14/2009
Time of Min Sample	12:00:00 PM	12:00:00 PM	12:00:00 PM	12:00:00 PM	12:00:00 PM	12:00:00 PM					7:40:00 AM	10:00:00 PM
Max Sample	24.2	24.6	23.2	23.9	23.5	23.1					176.4	15.3
Date of Max Sample	01/17/2009	01/17/2009	01/17/2009	01/17/2009	01/17/2009	01/17/2009					01/31/2009	01/15/2009
Time of Max Sample	5:50:00 AM	5:50:00 AM	5:50:00 AM	5:50:00 AM	5:50:00 AM	5:50:00 AM					2:20:00 PM	8:10:00 AM
Average Interval TI	0.09	0.09	0.1	0.09	0.11	0.1						
Wind Speed Direction							NW	NW				

Site Information:

Project: A3-1

Location:

Elevation: 307 m

Sensor Information:

1 NRG #40 Anem, m/s
2 NRG #40 Anem, m/s
3 NRG #40 Anem, m/s
4 NRG #40 Anem, m/s
5 NRG #40 Anem, m/s
6 NRG #40 Anem, m/s
7 #200P Wind Vane
8 #200P Wind Vane
9 No Sensor
10 No Sensor
11 NRG 110S Temp, C
12 iPack Voltmeter

February 2009

Summary Report

SITE 5643

New Ulm Wind Farm

Channel	1	2	3	4	5	6	7	8			11	12
Height	58	58	45	45	32	32	57	34			2	
Units	m/s	m/s	m/s	m/s	m/s	m/s	deg	deg			C	volts
Intervals with Valid Data	4032	4032	4032	4032	4032	4032	4032	4032			4032	4032
Average Filtered Data	7.47	7.67	7.08	7.33	6.73	6.92	294.08	290.05			163.22	13.86
Average for All Data	7.47	7.67	7.08	7.33	6.73	6.92	294.08	290.05			163.22	13.86
Min Interval Average	0.3	0.4	0.4	0.4	0.3	0.4					147.4	13.1
Date of Min Interval	02/05/2009	02/05/2009	02/04/2009	02/04/2009	02/04/2009	02/04/2009					02/03/2009	02/02/2009
Time of Min Interval	3:20:00 PM	2:10:00 PM	6:10:00 AM	6:10:00 AM	6:00:00 AM	6:00:00 AM					6:30:00 AM	9:30:00 PM
Max Interval Average	19.2	18.9	18	18.3	17.8	17.5					177	15.1
Date of Max Interval	02/10/2009	02/10/2009	02/09/2009	02/09/2009	02/10/2009	02/09/2009					02/09/2009	02/03/2009
Time of Max Interval	12:30:00 AM	12:30:00 AM	10:10:00 PM	10:10:00 PM	12:40:00 AM	10:10:00 PM					9:00:00 PM	8:10:00 AM
Average Interval SD	0.72	0.71	0.72	0.72	0.75	0.73	5.42	6.05			0.03	0.01
Min Sample	0.3	0.4	0.4	0.4	0.3	0.4					147.2	12.8
Date of Min Sample	02/04/2009	02/04/2009	02/04/2009	02/04/2009	02/04/2009	02/04/2009					02/03/2009	02/02/2009
Time of Min Sample	6:10:00 AM	6:20:00 AM	6:00:00 AM	6:00:00 AM	5:50:00 AM	5:50:00 AM					6:40:00 AM	9:30:00 PM
Max Sample	26.9	25.8	27.3	26.1	27.7	26.5					177.2	15.1
Date of Max Sample	02/10/2009	02/10/2009	02/10/2009	02/10/2009	02/10/2009	02/10/2009					02/09/2009	02/03/2009
Time of Max Sample	12:30:00 AM	12:30:00 AM	12:30:00 AM	12:30:00 AM	12:30:00 AM	12:30:00 AM					4:40:00 PM	8:00:00 AM
Average Interval TI	0.1	0.1	0.11	0.1	0.12	0.11						
Wind Speed Direction							NW	NW				

Appendix A-3

Data Quality Review – Sibley Met Tower Summary Report

(January 2009)

WindLogics
CONSULTING SERVICES

Data Quality Review – Sibley Met Tower
Summary Report

Prepared for:
New Ulm Public Utilities

Prepared by:
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January 23, 2009

Confidential Business Information

WindLogics

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New Ulm Public Utilities

Data Quality Review - Sibley Met Tower

Introduction

The purpose of this report is to communicate the results of a data quality review performed by WindLogics at the request of New Ulm Public Utilities (NUPU) on data from the "Sibley" meteorological data collection (met) tower, located in Sibley County, Minnesota. See Table 1 below for met tower location information.

Tower Name	Latitude (WGS 84)	Longitude (WGS 84)	Elevation (above mean sea level)
Sibley (Met 182)	N 44.52103	W 94.41036	1037 ft / 316 m

Table 1: Sibley Met Tower Location Information

The Sibley met tower data were obtained by NUPU from EAPC Architects and Engineers (EAPC) of Grand Forks, ND. The met tower data were collected at the Sibley site by EAPC and are being used by NUPU as a proxy met tower for their site, located approximately 7 miles from the Sibley tower. It is believed that the Sibley met tower data reflect the conditions at the NUPU site for the purposes of wind turbine suitability, but this is subject to verification that will be possible when sufficient met tower data collected have been collected at the NUPU site, which is currently ongoing.

This work is being pursued by NUPU in anticipation of installing wind turbines for purposes of generating electricity. The nominal hub height of the wind turbines planned for installation is 80 meters above ground level (m AGL).

Methods

Meteorological data were extracted from binary files created by AAT Solutions' data logger, as provided to WindLogics by NUPU. The data were extracted using AAT Solutions' "Go Logger" application and then run through WindLogics' automated met tower data quality control checking software. The resulting data and quality control information were then analyzed by WindLogics' staff using the Excel™ and Windographer™ software packages.

Information regarding boom and sensor orientations was provided to WindLogics. WindLogics did make some assumptions regarding the data and they are as follows:

- Wind speed data were in meters per second (m/s)
- Temperature data were in degrees Celsius (°C)
- Wind direction data had a 180° offset encoded in the data logger, as noted on the commissioning information provided to WindLogics
- All timestamps were in Central Standard Time (CST)

Results

Data Recovery and Screening

Meteorological data were collected at the Sibley tower during 14 months from November 13, 2007 to January 18, 2009. Data were collected at 10-minute intervals. The average values used in the analysis and stated in this report are reflective of the 10-minute interval data (as opposed to hourly average values).

Table 2, below shows the amount of data recovered from the data files, and how many timestamps were flagged during the automated data quality screening process. Please note that the height of the sensor, such as "60m (E)", is the distance in meters that the sensor is above ground level and orientation of the boom as a compass heading.

Channel Name	Variable Type	Total Timestamps	Missed Timestamps	Percent Received	Flagged Timestamps	Total Missing/Flagged Timestamps	Percent Not Missing/Flagged
Ch. 01 Anem. 60m (E)	Wind Speed	62,352	0	100.00	3,018	3,018	95.16
Ch. 02 Anem. 60m (W)	Wind Speed	62,352	0	100.00	2,962	2,962	95.25
Ch. 03 Anem. 50m (NW)	Wind Speed	62,352	0	100.00	2,917	2,917	95.32
Ch. 04 Anem. 40m (NW)	Wind Speed	62,352	0	100.00	3,234	3,234	94.81
Ch. 05 Vane 58m (N)	Wind Direction	62,352	0	100.00	9,658	9,658	84.51
Ch. 06 Vane 38m (N)	Wind Direction	62,352	0	100.00	10,130	10,130	83.75
Ch. 07 Temp. 3m	Temperature	62,352	0	100.00	9,608	9,608	84.59
	Totals	436,464	0	100.00	41,527	41,527	90.49

Table 2: Sibley Met Tower Data Recovery Summary

Sensor-By-Sensor Data Quality Analysis

A breakdown of the data quality for each of the sensors on the Sibley met tower is as follows:

- All Sensors: There are no significant gaps in the wind speed sensor data record that were observed. Larger gaps for the wind direction and temperature sensors are apparent. All data collected from February 15, 2008 to April 14, 2008 are intermittent, or non-existent, potentially due to an icing event which damaged the sensors. Other minor gaps in the data record exist, but did not occur for more than 24 hours at a time.
- Ch. 01 Anem. 60m E (wind speed at 60m AGL): As can be seen in Table 2, 95.16% of the data collected by this sensor during the data collection period were un-flagged. The resulting average wind speed was 7.55 meters per second (m/s). The amount of un-flagged data and the patterns of data seen would indicate that this sensor was functioning normally during most of the collection period.
- Ch. 02 Anem. 60m W (wind speed at 60m AGL): As can be seen in Table 2, 95.25% of the data collected by this sensor during the data collection period were un-flagged. The resulting average wind speed was 7.71 m/s. The amount of un-flagged data and the patterns of data seen would indicate that this sensor was functioning normally during most of the collection period.
- Ch. 03 Anem. 50m NW (wind speed at 50m AGL): As can be seen in Table 2, 95.32% of the data collected by this sensor during the data collection period were un-flagged. The resulting average wind speed was 7.22 m/s. The amount of un-flagged data and the patterns of data seen would indicate that this sensor

was functioning normally during most of the collection period. Even though the data collection appears to be functioning normally, there is reason to believe that there may be a problem with this sensor, see 'Wind Shear and Hub-Height Wind Speeds' section, below.

- Ch. 04 Anem. 40m NW (wind speed at 40m AGL): As can be seen in Table 2, 94.81% of the data collected by this sensor during the data collection period were un-flagged. The resulting average wind speed was 7.13 m/s. The amount of un-flagged data and the patterns of data seen would indicate that this sensor was functioning normally during most of the collection period.
- Ch. 05 Vane 58m N (wind direction at 58m AGL): As can be seen in Table 2, 84.51% of the data collected by this sensor during the data collection period were un-flagged. The somewhat low rate of return for this sensor was due to problems with the sensor following outages during the time periods from January 10-16, February 15 to April 14, and December 14-23, 2008. The cause of the problems with the sensor is unknown, but icing events appear to be a potential cause. The data that do exist indicate predominant wind directions from the south during the summer and the northwest during the winter (see Figure 1).

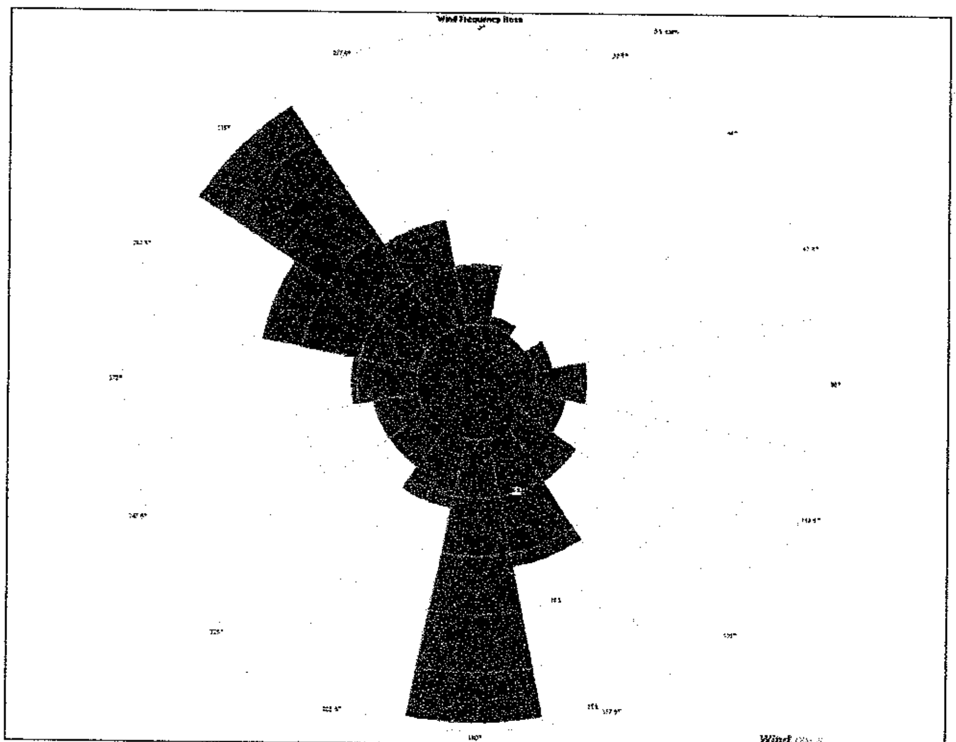

Figure 1: Wind Rose at 58m AGL

- Ch. 06 Vane 38m N (wind direction at 38m AGL): As can be seen in Table 2, the results of the automated data quality screening indicated that 83.75% of the data collected by this sensor during the data collection period were un-flagged. The somewhat low rate of return for this sensor was due to problems with the sensor following outages during the time periods from January 10-16, February 15 to April 14, and December 14-23, 2008. The cause of the problems with the sensor is unknown, but icing events appear to be a potential cause. The data that do exist indicates predominant wind directions from the south during the summer and the northwest during the winter (see Figure 2).

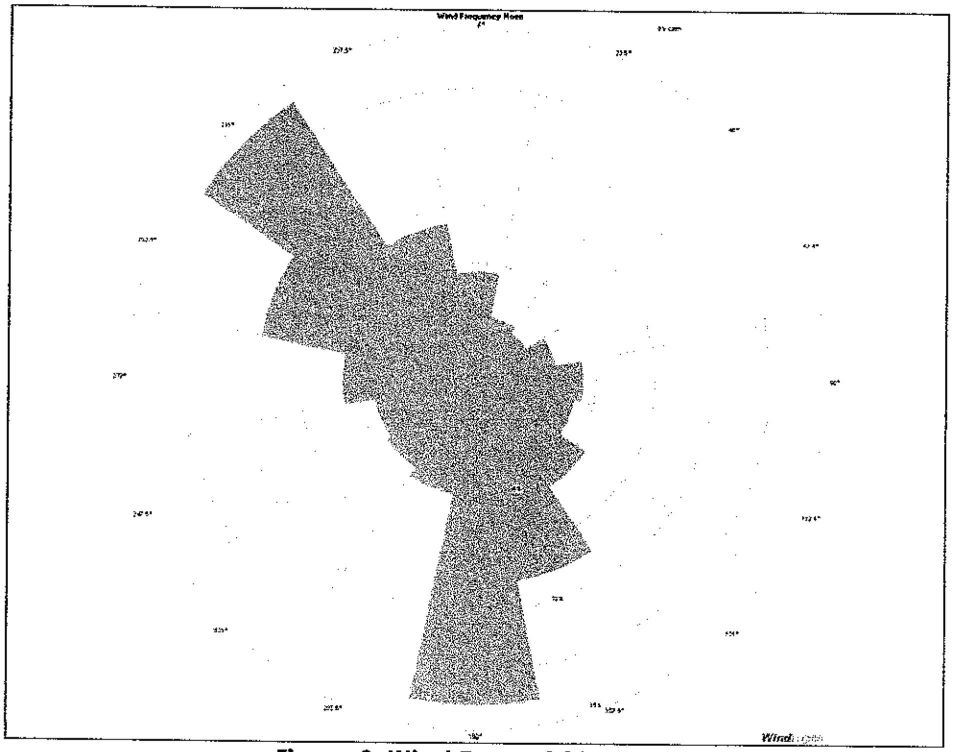

Figure 2: Wind Rose at 38m AGL

- Ch. 09 Temp. 3m (air temperature at 3m AGL): As can be seen in Table 2, 84.59% of the data collected by this sensor during the data collection period were un-flagged. The somewhat low rate of return for this sensor was due to problems with the sensor following outages during the time period from February 15 to April 14, 2008. The overall average temperature for the data collection period was 4.5° C (40° F).

Identified Inter-Sensor Problems

There are a few issues with the data collected at the Sibley site that become apparent when comparing data from multiple sensors:

- As mentioned in the 'Sensor-By-Sensor Data Quality Analysis' section, the 58m AGL and 38m AGL wind direction vanes, along with the 3 m AGL temperature sensor, had significant difficulties during most of the two months from February 15 to April 14, 2008. The wind direction data from this period were clearly bad, and were removed from the dataset. The wind speed data from this period were more problematic. It appeared that some of the data were good, while interspersed with the good data were periods that were not. The reason behind the odd behavior of the anemometers during this time was not found, and it was ultimately decided, absent a definite reason to take it out, to leave the wind speed data in the dataset. See Figure 4, below, for a graphical depiction of the data during this period. In the figure, time series of wind directions at 58m AGL and 38m AGL, with temperature at 3m AGL, are shown on top, while wind speeds at 60m AGL (east and west orientation), 50m AGL, and 40m AGL are shown on the bottom. The odd behavior can be clearly seen for the time period for which the wind direction data have been removed. Should a definite reason for the odd behavior be found, or if data quality requirements become stricter, it may be decided that the wind speed data during this time period should also be removed from the dataset.

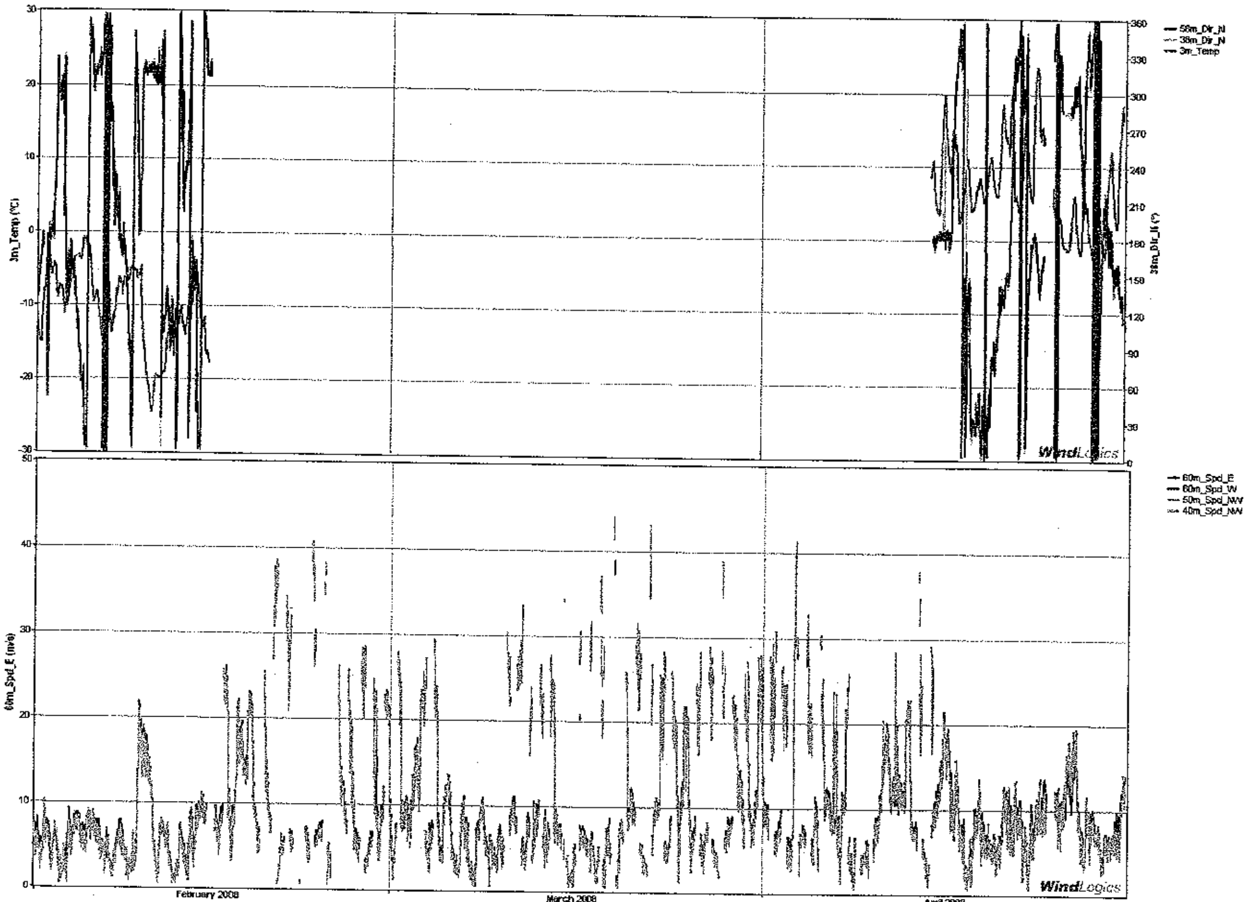

Figure 3: Wind speed and direction comparison for the time period from February to April 2008

- The two anemometers at 60m AGL disagree by an average value of 0.16 m/s, which is a fairly slight amount of difference for sensors at the same height. One source of this discrepancy is tower shadow. Tower shadow occurs when one sensor is shielded by the tower, resulting in a lower wind speed. Tower shadow plots were examined, and some shadowing is seen, see Figure 5 for an example. Figure 5 shows the "60m E" (Ch. 01 Anem. 60m) sensor minus the "60m W" (Ch. 02 Anem. 60m) sensor. As can be seen from the figure, there is a significant difference in wind speeds near 270 degrees (boom orientation relative to true north). These differences would appear to indicate that tower shadow is playing a role in the measurement of wind speed at 60m AGL from this direction.

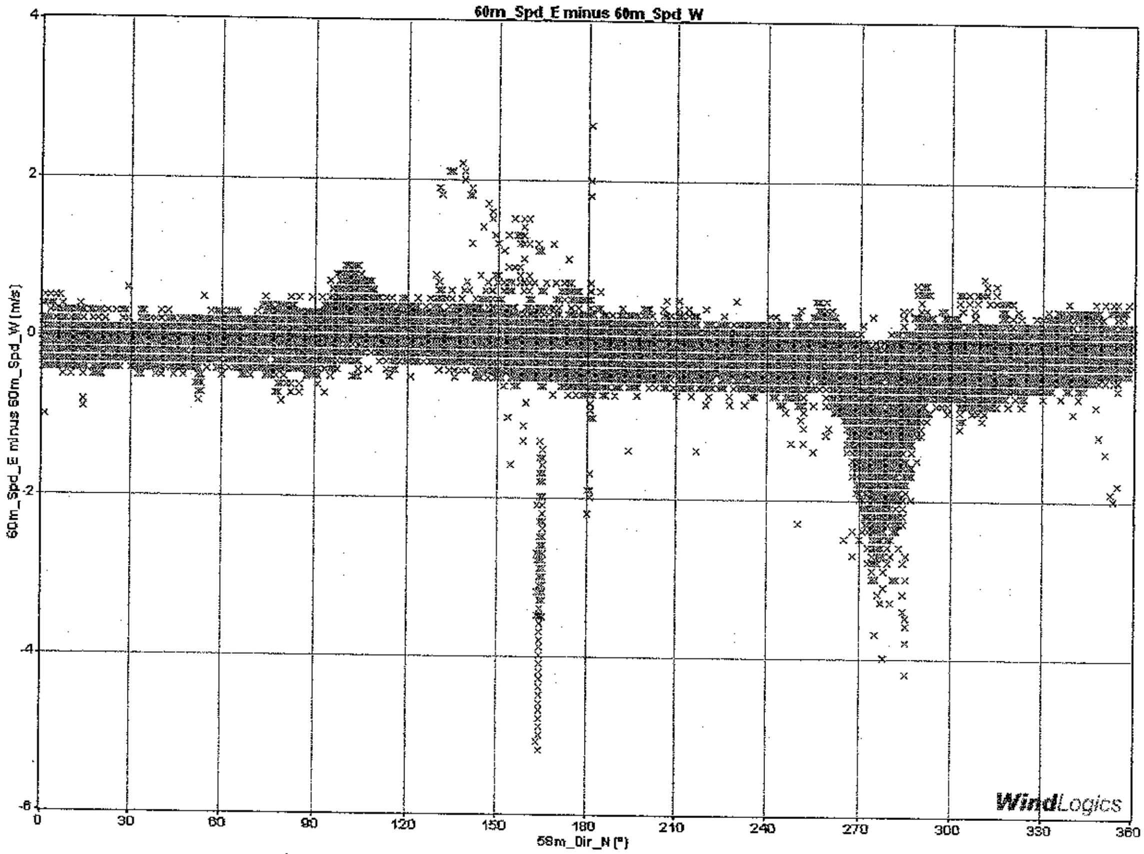

Figure 4: Tower shadow analysis at 60m AGL

Wind Shear and Hub-Height Wind Speeds

The goal of any wind resource analysis is to assess the wind's ability to drive wind turbines at specific locations and heights. It is often only possible to measure the wind at lower heights than the typical height of the turbine. This requires that the hub-height wind speed be estimated from the measured data.

Estimating hub-height wind speeds from measurements at lower heights requires the use of a *wind shear exponent*, commonly referred to as α (alpha), which is a value showing the relationship between wind speeds at an upper and a lower height. This value is then used in the *power law* equation to calculate wind speeds at hub height. Table 3 shows a summary of five different wind shear scenarios for comparison and their estimated hub-height (80m AGL) wind speed values.

Upper Anemometer	Lower Anemometer	Shear Exponent (alpha)	Estimated 80m AGL Wind Speed (m/s)
Ch. 01 Anem. 60m (E)	Ch. 04 Anem. 40m (NW)	0.163	7.94
Ch. 02 Anem. 60m (W)	Ch. 04 Anem. 40m (NW)	0.214	8.19
Ch. 01 Anem. 60m (E)	Ch. 03 Anem. 50m (NW)	0.293	8.23
Ch. 02 Anem. 60m (W)	Ch. 03 Anem. 50m (NW)	0.407	8.68
60mE and 60mW Maximum	Ch. 04 Anem. 40m (NW)	0.224	8.32

Table 3: Summary of Wind Shear Values and Estimated Hub-Height Wind Speeds

The wind shear and estimated 80m AGL wind speed values in Table 3 are based on the period for which overlapping data were available from all the three sensors during the data collection period. Also presented are the shear and hub-height extrapolated wind speed using the maximum value between the "60m E" and "60m W" sensors at each time step. The maximum value is calculated in order to reduce the tower shadow effect as demonstrated in Figure 5. Using the maximum value of the two 60m AGL wind speed sensors and the 40m AGL wind speed sensor, an average shear exponent of 0.224 and estimated average 80m AGL wind speeds of 8.32 m/s were present during the 14-month data collection period.

The shear value calculated using the 60m AGL and the 50m AGL wind speed sensors appears to be abnormally high for southern Minnesota, at 0.407. This appears to indicate that the 50m AGL sensor may have been reporting slightly lower than expected.

Conclusions and Recommendations

A thorough quality checking and analysis process was performed by WindLogics on meteorological data provided by New Ulm Public Utilities for the Sibley met tower. Data quality issues were identified, particularly the two-month gap in wind direction and temperature data in early 2008, and the possibility that the wind speed data for this time period could be removed from the dataset (wind speed data were not removed at this time). The data collected after the outage period indicates that the sensors on the Sibley tower resumed operation and are currently working properly. However, after such a data outage, it is often beneficial to inspect the sensors on the tower and re-calibrate and/or replace sensors as needed. Overall, the rate of data outages, recovery rates and the tower shadowing effects are within expected ranges.

Despite the met tower data quality issues found at the Sibley location, the bulk of the data collected are consistent with a hub-height wind speed of approximately 8.3 m/s, which indicates that a "~~moderate-to-good~~" wind resource during the collection time period at the Sibley site.

July 9, 2007

The WindLogics® analysis (Appendix A-1) estimated an average December wind speed of 8.18 m/s - 8.50 m/s (18.3 mph) at 80 m. The average December 2008 wind speed recorded at the NUPUC on-site meteorological tower at 58 m was 7.93 m/s (17.7 mph) for the month (Appendix A-2). Using the data from the 58 m and the 45 m anemometer of 7.59 m/s (16.9 mph), a wind speed of 8.50 m/s (19.0 mph) can be extrapolated at 80 m.

July 9 2007

The WindLogics® analysis (Appendix A-1) estimated a normalized average January wind speed of 8.38 m/s - 7.93 m/s (18.7 mph) at 80 m. The January 2009 average wind speed at 58 m was 7.30 m/s (16.3 mph) for the month (Appendix A-2). Using the data from the 58 m and 45 m anemometer of 6.93 m/s (15.5 mph), a wind speed of 7.93 m/s (17.7 mph) can be extrapolated at 80 m.

July 2007

The WindLogics® analysis (Appendix A-1) estimated a normalized average February wind speed of 8.01 m/s - 8.24 m/s (17.9 mph) at 80 m. The February 2009 average wind speed at 58 m was 7.67 m/s (17.1 mph) for the month (Appendix A-2). Using the data from the 58 m and 45 m anemometer of 7.33 m/s (16.4 mph), a wind speed of 8.24 m/s (18.4 mph) can be extrapolated at 80 m.

In addition to the on-site data currently being collected, the NUPUC has obtained wind data from 2 additional sources. The NUPUC purchased and contracted with WindLogics® to perform a data quality review summary report of the wind data from the Sibley meteorological tower located 7 miles north of the NUPUC Project site. This data comprises 1 year of monitoring compiled on a 60 m tower. The WindLogics® data quality review analysis, attached as Appendix A-3, indicates an average annual hub height wind speed of approximately 8.3 m/s (18.6 mph).

2.3.1 Interannual Variation

As indicated above, from the WindLogics® Wind Resource Analysis, the expected annual average wind speed at the Project site is approximately 8.3 m/s at an 80 m hub height (18.6 mph at 262 feet). The Minnesota Wind Resource Analysis Program (WRAP) 7 years of data from the 70 m Mountain Lake meteorological tower near Darfur, has an expected average wind speed of 7.3 m/s (16.3 mph) at a 70 m and would yield a wind speed of 8.0 m/s (17.9 mph) that can be extrapolated at 80 m. The Mountain Lake meteorological tower is located within 50 miles of the NUPUC Project site and is the only tower officially reported with at least 7 years of continuous 70 m wind speed data as shown in Appendix A-4.

SAME AS SIBLEY?

DOES NOT SHOW ON COMMERCIAL MAPS

2.3.2 Seasonal Variation

Data collection from the NUPUC on-site meteorological tower is ongoing; therefore the seasonal variation of the predicted monthly average wind speeds for the Project site at a hub height of 80 m (262 feet) is being developed. The meteorological tower recorded the highest wind speed in December of 8.51 m/s (19.0 mph).

The NUPUC Project site wind speeds are consistent with the characteristics of other wind resources within Minnesota, which are generally highest in the fall, winter, and spring months. Wind speed decreases during the late spring and summer months (May through August).

2.3.3 Diurnal Conditions

Three months of information, December 2008, January 2009, and February 2009, have been recorded by the NUPUC on-site 60 m meteorological tower and provided a sampling of the diurnal variation of wind speed at the Project site. Representation of the variability of wind speed over the course of a 24-hour period is presented in Graphics 2-1, 2-2, and 2-3 on the following pages. The meteorological tower wind summary report for December, January, and February are included as Appendix A-2. The conditions encountered indicate increasing wind speed in the afternoon hours as the temperature reaches daytime highs. The range of wind speed has been recorded at 6 m/s (13.4 mph) in the morning to a high in excess of 17 m/s (38 mph). The average wind velocity at 58 m for December 2008 was 7.8 m/s (17.4 mph); January 2009 was 7.2 m/s (16.1 mph); and February 2009 was 7.6 m/s (17.0 mph). The maximum 58 m wind speed recorded was in December 2008 at 19.5 m/s (43.6 mph). Wind speeds at high levels tend to decrease in the morning because of the warming effects of the sun on the earth, resulting in a mixing of winds.

WHY ARE WE GETTING MET TOWER READINGS FROM (1) SIBLEY (2) MOUNTAIN LAKE TO JUSTIFY WIND HERE?