GLOBAL ENERGY CONCEPTS

THE Wind Resource

Wind Energy Feasibility Study

July 2005

Prepared for:

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Section 1 - Introduction

The Sault Ste. Marie Tribe of Chippewa Indians (the Tribe) hired Global Energy Concepts, LLC (GEC) to perform a wind energy feasibility study of their tribal lands. The feasibility study was conducted through the U.S. Department of Energy (DOE) Renewable Energy Development on Tribal Lands Fund. The study provides for a wind resource assessment program that includes the purchase and installation of five meteorological (met) towers, data collection, and periodic reporting. As a part of the Tribe's commitment to the environment, they desire to install a wind turbine on tribal land near electrical local loads such as a casino, health center, community center, or tribal housing development.

GEC visited several tribal properties to recommend sites for met tower placement. Though the windiest sites in Michigan are along the coastline, the Tribe was determined to locate turbines as near to tribal electric load as possible. Working closely with the Tribe, five sites were chosen: Wetmore, Odenaang, St. Ignace, Manistique, and Newberry. Two of these sites, while not on the coast, were near the coast. One tower was placed at each site and the towers ranged in height from 30 m to 50 m. After a year of data collection, St. Ignace and Manistique, the two sites nearest the coast, proved to be the windiest, recording average wind speeds over 5 m/s at 40 m. Though these winds are not strong enough to justify multi-megawatt turbines, GEC investigated the feasibility of using small turbines in the 10 kW to 100 kW range, which may be suitable for a net metering arrangement and for which significant grant funds may be available.

Moving forward with these two sites, GEC picked two small-scale turbines for the sites, the 10 kW BWC Excel-S manufactured by Bergey Windpower Company (Bergey) and the 50 kW (maximum 66 kW) EW15 manufactured by Entegrity Wind Systems[1]. Since the capacity of these two turbines is smaller than the loads at the St. Ignace casino and Manistique health center, the output will be used to offset electricity supplied by Edison Sault Electric. With appropriate setbacks, each turbine, situated on a 120-ft (36.6-m) tower, fits into each space. However, since both sites are near airports, a Federal Aviation Administration (FAA) permit for construction will be required.

The Tribe may also need to conduct an environmental assessment (EA) of each site since Mackinaw and Schoolcraft counties have several threatened and endangered species. However, since major construction started on a new casino at St. Ignace in 2004 and a new health center at Manistique was completed in 2003, EAs from those jobs may be adequate for use in siting the turbines. Turbines of the size proposed in this study normally disturb only a very small area.

Given the measured wind speed and frequency distribution, the resultant expected annual energy is not sufficient to make the projects economical at this time. The turbines would only offset 4.2 ¢/kWh energy, and with current 2004-2005 technology, these smaller systems need to be located in areas of 8-10 ¢/kWh energy to be economically viable. At the time of this report Michigan also offers little incentive to installers/owners of small-wind projects.

[1] Entegrity Wind Systems used to be Atlantic Orient Corporation, which manufactured the AOC15/50. A similar machine is manufactured by Atlantic Orient of Canada, Inc., which was an affiliate of Atlantic Orient Corporation.

Section 2 - Site Selection and Wind Resource Assessment

2.1 Site Selection

Figure 2-1 presents the National Renewable Energy Laboratory's (NREL) wind map for the eastern half of the Upper Peninsula (UP) of Michigan. The colors represent approximate average wind speeds at 50 m above ground. Inland UP is characterized by average wind speeds of 13.4 mph (6.0 m/s) or lower. However, pockets of higher wind speeds may exist, which necessitates placement of a met tower at a proposed site to understand the local wind resource. The higher wind areas occur along the coast of the UP and offshore. Barring other concerns, these would be the more ideal locations for a met tower and possible wind turbine.

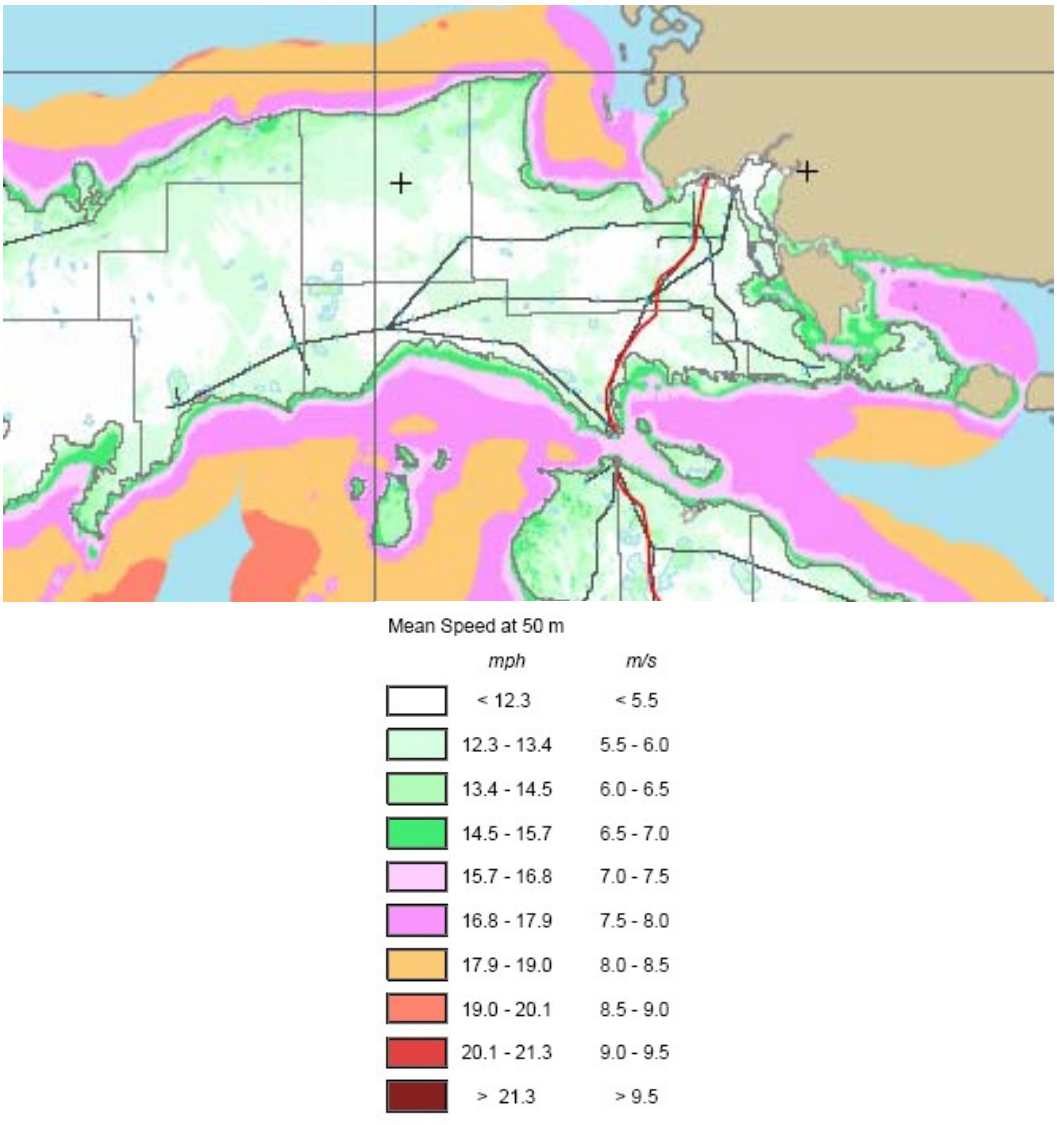

Figure 2-1.
Snapshot of Eastern UP Wind Resource Map

Although the Tribe owns several properties throughout the eastern half of the UP, most of the property with electrical load and near electric transmission lines is inland. GEC with the assistance of Robert Owen, a wind energy meteorologist, visited these properties as well as nearby non-tribal land to determine the optimum location for five metrological towers (met towers), as shown in Table 2-1. Within the 10 general areas visited, GEC and Mr. Owen recommended 12 sites to the Tribe for consideration. The recommended sites provided a mix of potentially good wind resource, sufficient electric load, and access to transmission. See Appendix A for Mr. Owen's detailed site report.

Table 2-1.
Initial Recommendations

Parcel No.	Name[1]	County	Met Site?	Reason not
	Kelly Road (10) [NT]	Schoolcraft	Yes	
	Marquette Mountain (1) [NT]	Marquette	Yes	
	Quarry near casino (2) [NT]	Alger	Yes	
AC-007	Wetmore housing (3)	Alger	Yes	
LC-001	Newberry housing (4)	Luce	Yes	
CC-048	Odenaang (5)	Chippewa	Yes	
	NE of M-28 & Maple N (5) [NT]	Chippewa	Yes	
	Near I-75 & M-28 (5) [NT]	Chippewa	Yes	
	Near Moran (8) [NT]	Mackinac	Yes	
MC-004	Fisheries (7)	Mackinac	Yes	
MC-009	King Prop.-Naubinway (9)	Mackinac	Yes	
	Pawley Farm (10) [NT]	Schoolcraft	Yes	
MC-001	St. Ignace Casino (8)	Mackinac	Maybe	Room? Safe?
	Lighthouse-Manistique Harbor (10)	Schoolcraft	Maybe	USCG slow?
MQ-002	Eagle Ridge Apts.	Marquette	No	Poor wind
MQ-001	Marquette Housing	Marquette	No	No room
AC-002	Munising Tribal Hlth Ctr	Alger	No	Poor wind
AC-006	Christmas Casino	Alger	No	No room
CC-003	Vegas Kewadin Casino	Chippewa	No	Poor wind
CC-015	Big Bear (Chi Mukwa)	Chippewa	No	Poor wind
Many	Parcels near above two	Chippewa	No	Poor wind
CC-005	Bahwetting School	Chippewa	No	Poor wind
CC-029	Tribal Health Center	Chippewa	No	Trees
Several	Parcels near Hlth Ctr	Chippewa	No	No room
SC-001	Manistique Casino	Schoolcraft	No	Near airport
SC-002	Manistique Housing	Schoolcraft	No	No room
SC-003	West U.S. 2 Prop.	Schoolcraft	No	Near airport
SC-004	Kewadin Inn-Manistique	Schoolcraft	No	No room

[1] The number in parentheses corresponds to the numbered areas designated in Mr. Owen's trip report, included in Appendix A. NT indicates sites not located on tribal land.

Table 2-2 presents a more detailed account of the recommended sites. This table includes an additional site, the St. Ignace Casino. GEC moved this site from "maybe" to a potential site due to the Tribe's belief that a wind turbine at this site could be good publicity for the Tribe and attract visitors to the casino. Therefore, the Tribe made land available at this site. The table includes six sites on tribal property and seven sites on non-tribal land.

Table 2-2.
Potential Monitoring Sites for the UP

Tribal-Owned Properties					
Area Designation[1]	**Site Description**	**County**	**Priority Rating**	**Exposure**	**Nearby Electrical Load**
5	Odenaang	Chippewa	High	Very good	36 homes, close to SSM facilities
3	Wetmore housing	Alger	Mod	Fair	19 homes
4	Newberry housing	Luce	Mod	Fair	24 homes, Newberry Health Center
8	St. Ignace Casino	Mackinac	Low-Mod	Fair-good	59 homes, Lambert Center, St. Ignace Casino & Midjim
7	Fish hatchery	Mackinac	Low-Mod	Fair plus	former fish hatchery
9	King Prop.-Naubinway	Mackinac	Low	Fair	1 home
Non-Tribal Properties					
Area Designation[1]	**Site Description**	**County**	**Priority Rating**	**Exposure**	**Nearby Electrical Load**
5	NE of M-28 & Maple N	Chippewa	High	Very good	no on-site load, for Sault Ste. Marie
8	Near Moran	Mackinac	High	Very good	no on-site load, for St. Ignace
2	Quarry near casino	Alger	Mod-High	Fair-Good	may interconnect to the Christmas Casino
5	Near I-75 & M-28	Chippewa	Mod-High	Good	no on-site load, for Sault Ste. Marie
1	Marquette Mountain	Marquette	Mod	Very good	no on-site load, for Marquette
10	Pawley Farm	Schoolcraft	Mod	Fair	no on-site load, for Manistique
10	Kelly Road	Schoolcraft	Mod	Fair	no on-site load, for Manistique

[1] This number corresponds to the numbered areas designated in Mr. Owen's trip report in Appendix A.

The Tribe required that turbines be on tribal land. Of the six tribal sites listed in Table 2-2, four were chosen for met tower installation. The fifth site, originally listed as not recommended due to its proximity to an airport, was chosen for a met tower because of increasing electrical load at the site. Table 2-3 presents the five sites at which met towers were installed, along with the installation date and approximate sensor heights. Figure 2-2 shows their locations within the eastern UP.

Table 2-3.
Monitoring Site Summary

Site Number	Location	Coordinates (NAD 27)	Wind Speed Levels (m) [1]	Commissioning Date
8001	Wetmore	N46°23'11", W86°37'22"	40, 30, 20	October 8, 2003
8002	Odenaang	N46°26'51", W84°20'01"	40, 30, 20	October 9, 2003
8003	St. Ignace	N45°55'39", W84°43'59"	50, 40, 30	October 12, 2003
8004	Manistique	N45°58'10", W86°09'41"	40, 30, 20	November 20, 2003
8005	Newberry	N46°18'11", W85°29'04"	30, 10	November 21, 2003
[1] Wind speed sensor levels are approximate heights above ground level.				

Figure 2-2.
Map of Met Tower Locations[2]

[2] Source: Microsoft Streets & Trips 2002.

2.2 Descriptions of the Selected Sites

2.2.1 Wetmore in Alger County

The Wetmore site comprises a tribal housing development and a maintenance building. These structures are individually metered under single-phase service from Upper Peninsula Power Company. Some undeveloped land is located to the west and northwest of the structures. Figure 2-3 shows an aerial photo of the site circa 1993[3]. By the time of the site visit in 2003, the dirt track, in the center of the photo, was rarely used and the trees had overtaken the area. The met tower is located in this undeveloped area.

Figure 2-3.
Wetmore on May 7, 1993

[3] The aerial photos used in Figure 2-3 through Figure 2-7 were obtained from TopoZone.com @ 1999-2004. Maps a la carte, Inc.

2.2.2 Odenaang in Chippewa County

The Odenaang site comprises approximately 300 acres of farm land as shown in Figure 2-4. Not shown on this 1998 photo is a housing development in the southern portion of the property. This site is large enough to accommodate utility-scale wind turbines if the wind resource warrants. However, this could constrain future housing developments in the northern portion of the property. Load at the site consists of residential housing while larger tribal loads are located approximately 3 miles north of this property. The met tower is located in the northeast corner of the site.

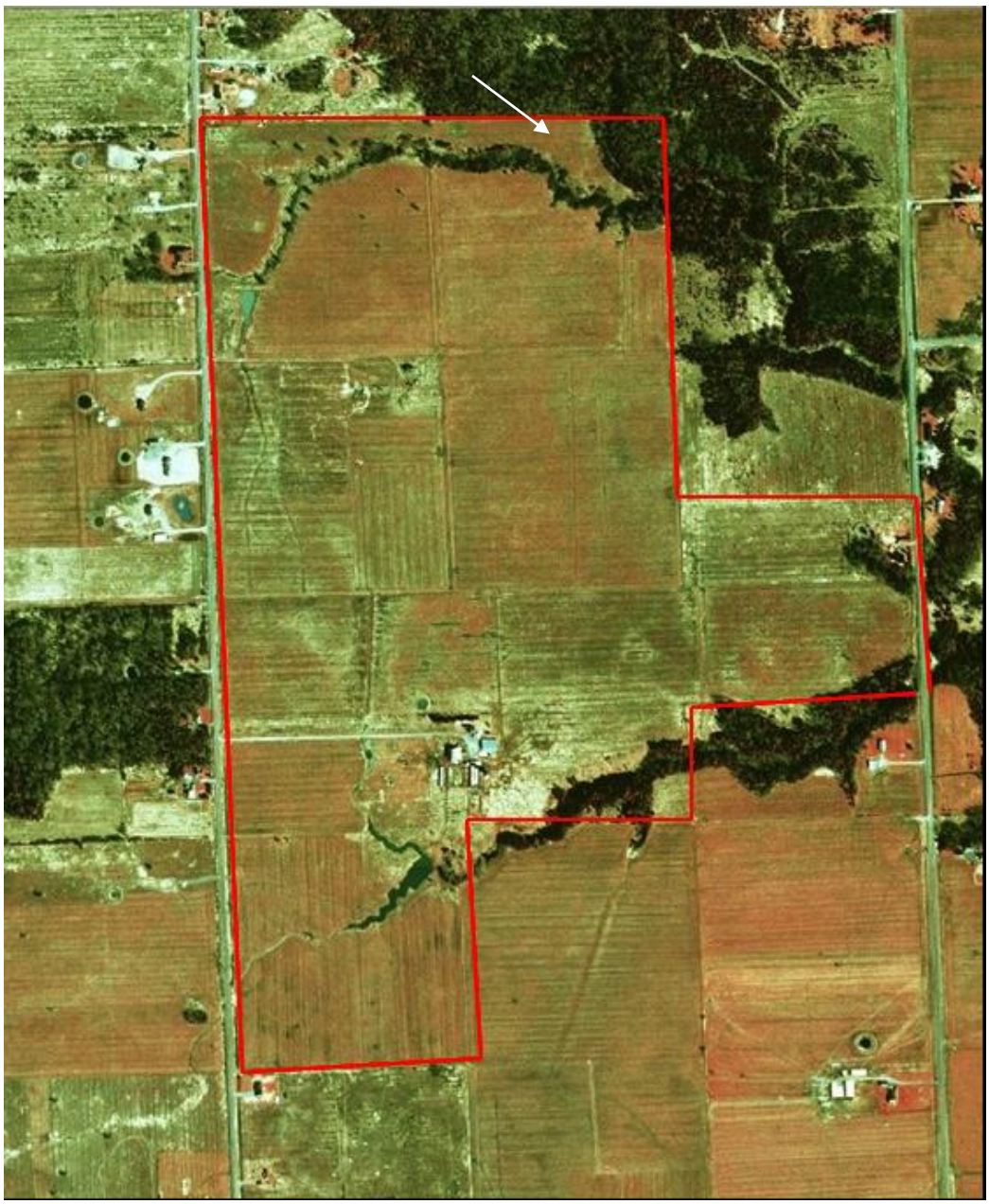

Figure 2-4.
Odenaang on April 28, 1998

2.2.3 St. Ignace in Mackinac County

As shown in Figure 2-5, the St. Ignace Casino site has a fairly large sized area that could accommodate a large-scale wind turbine depending on the location of the casino expansion. The area consists of an abandoned quarry (the bright area near the center of the photo) that is surrounded by trees approximately 30 ft in height. This photo predates the current casino development. The met tower is sited near the edge of the Rabbit Back Hill to take advantage of winds that may accelerate over the hill. A turbine located in this area should benefit from proximity to Lake Huron and any winds coming off the lake. The casino load should be sufficient to warrant either a small or large turbine. Of some concern is the proximity of the site to the Mackinac County Airport. The airport sits at a lower elevation, approximately 2 miles south of the St. Ignace Casino. Though FAA approval was not obtained for the met tower, FAA approval may be necessary for a turbine installation, and could limit the height of a wind turbine placed on the site.

Figure 2-5.
St. Ignace on April 28, 1998

2.2.4 Manistique in Schoolcraft County

The Manistique site is located just southeast of the Schoolcraft County Airport. Currently a 99-ft sign advertising the casino is located on U.S. Highway 2, just south of the met tower location. FAA approval was not obtained for this sign nor has anyone filed a complaint. Even so, FAA approval would be required for any turbine sited on this land. The area between these two facilities could accommodate a wind turbine with reasonable setbacks from the parking lots. Though more land is available north of the facilities, which would increase the setback from the parking lot, this would also locate the turbine closer to the airport. Figure 2-6 shows how the site looked in 1998. The area is relatively flat and clear of trees. The met tower is located between the casino and health center, which maximizes the distance from the airport's east-west runway while maintaining a reasonable distance from existing structures.

Figure 2-6.
Manistique on April 28, 1998

2.2.5 Newberry in Luce County

This area is situated on a reasonably large plateau surrounded by lower terrain at a distance of a few miles. Newberry has a housing enclave similar to Wetmore but also includes a tribal health center as shown in Figure 2-7. It may be possible to offset the load at the health center with a small wind turbine. The site has one small area of land available upon which one small turbine (e.g., 10 kW turbine on a 100-ft tower) could fit with reasonable setbacks from the road and health center parking lot. The area is also near the Luce County Airport. FAA restrictions may limit the turbine height or prevent the installation of a turbine at this site. The met tower is located in the open, grassy area north of the health center.

Figure 2-7.
Newberry on April 9, 1998

2.3 Wind Resource at the Selected Sites

Starting in October and November 2003, GEC collected wind resource information from the met towers located at the five sites. Data collected included wind speed, wind direction, temperature, and pressure. GEC validated the data collected and provided quarterly reports to the Tribe. The following summary of the annual wind resource includes monthly data recovery and average wind speeds, annual frequency distributions, directional and diurnal analysis, and wind shear and turbulence intensity analyses. All analyses included in the wind resource summary are based on the time periods described in the Data Recovery section.

2.3.1 Data Recovery

Table 2-4 provides the monthly data recovery rates for the upper sensor of each tower. For Sites 8001, 8002, and 8003, data are included from November 1, 2003, through October 31, 2004. For Sites 8004 and 8005, data are included from December 1, 2003, through November 30, 2004. The overall data recovery rates are very high with a greater than 99% average at all sites. During the winter months, sensor icing caused some data loss.

Table 2-4.
Wind Speed Data Recovery

	Site Number and Location				
	8001 Wetmore	**8002 Odenaang**	**8003 St. Ignace**	**8004 Manistique**	**8005 Newberry**
November 2003	100.0%	100.0%	100.0%		
December	100.0%	96.0%	100.0%	100.0%	91.8%
January 2004	99.5%	100.0%	100.0%	100.0%	100.0%
February	100.0%	100.0%	95.1%	94.4%	100.0%
March	98.3%	100.0%	96.4%	100.0%	100.0%
April	99.2%	100.0%	100.0%	98.5%	100.0%
May	100.0%	100.0%	99.9%	100.0%	99.9%
June	100.0%	100.0%	100.0%	100.0%	100.0%
July	100.0%	100.0%	100.0%	100.0%	100.0%
August	100.0%	100.0%	100.0%	100.0%	100.0%
September	100.0%	100.0%	100.0%	100.0%	100.0%
October	100.0%	100.0%	100.0%	100.0%	100.0%
November				100.0%	100.0%
Overall Average	**99.7%**	**99.7%**	**99.3%**	**99.4%**	**99.3%**

2.3.2 Measured Wind Speed

The monthly average wind speeds for the upper level are summarized in Table 2-5. For comparison purposes, Table 2-5 also includes the 40-m wind speeds for St. Ignace. The 40-m wind speeds are shown graphically in Figure 2-8, with the exception of Newberry at 30 m. The winds are somewhat higher at St. Ignace and Manistique than at the other sites. As shown in the figure, the winds are generally higher in the spring and fall and lower in the summer and winter. Although the velocity of the wind varies, the monthly wind speed patterns are similar at all of the sites with the exception of Site 8001, Wetmore. The winds at Wetmore follow the monthly pattern of the other sites during the majority of the year; however, there appears to be greater

month-to-month variation at Wetmore. In addition, the average wind speed at Wetmore increased noticeably from August to September, whereas the winds decreased or stayed relatively constant at the other four sites.

Table 2-5.
Summary of Monthly Average Wind Speeds (m/s)

	Site Number and Location					
	8001 Wetmore	8002 Odenaang	8003 St. Ignace		8004 Manistique	8005 Newberry
	40 m	40 m	50 m	40 m	40 m	30 m
November 2003	4.7	4.7	6.0	5.7		
December	5.1	4.0	5.6	5.2	5.5	3.9
January 2004	4.9	3.6	5.7	5.4	5.1	3.8
February	4.3	3.9	5.7	5.3	5.0	4.0
March	5.4	4.4	5.9	5.4	5.6	4.5
April	4.4	4.3	5.4	5.1	5.1	4.1
May	4.9	4.1	5.1	4.8	5.3	4.5
June	4.1	3.9	5.2	4.8	4.6	3.8
July	3.6	3.3	4.5	4.1	4.3	3.3
August	4.1	3.9	5.2	4.7	4.8	3.9
September	4.7	3.7	5.1	4.6	4.8	4.0
October	4.9	4.3	5.8	5.3	5.4	4.1
November					4.8	3.9
Annual Average	**4.6**	**4.0**	**5.4**	**5.0**	**5.0**	**4.0**

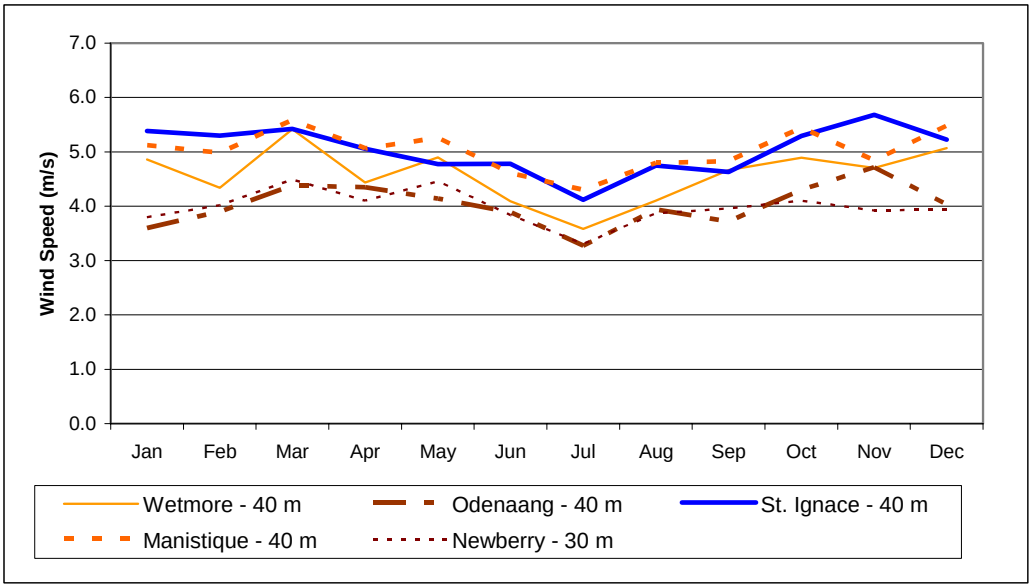

Figure 2-8.
Monthly Wind Speeds

2.3.3 Long-Term Adjusted Frequency Distribution

To determine if the period of record is representative of the long-term wind resource, GEC identified a long-term reference station at the Pellston Regional Airport. The airport is located approximately 15 miles south of St. Ignace. While this is the closest airport to St. Ignace, it is not very close to the other monitoring sites. However, summarized data were not readily available from other airports in or near the UP. To establish the relationship between the Pellston Airport and the monitoring sites, GEC performed a linear regression analysis of the concurrent daily wind speeds. The degree of correlation is expressed as an r-square value where 1.0 is a perfect correlation. Typically, the closer two sites are to each other the higher the r-square. The analysis of the relationship between the airport and St. Ignace resulted in an r-square of 0.80, a fairly close correlation. As expected, the correlation to Manistique, which is approximately 75 miles east of the airport, was lower with an r-square of 0.75.

Since a reasonable relationship exists between the airport and the UP winds, GEC reviewed the wind speeds available from the airport to determine if the period of record is representative of the long-term wind resource. Ideally, a long-term reference site will have 10 or more years of data. Unfortunately, data for the Pellston airport are only readily available from August 2000, a period of four years. Although less than ideal, the airport data provide some valuable indications. As shown in Table 2-6, the annual average wind speed at the airport was 7.9 mph (3.5 m/s) for each of the calendar years from 2001 through 2003. In addition, the average monthly wind speed was 7.9 mph (3.5 m/s) for the monitoring period, November 1, 2003, through October 31, 2004.

Table 2-6.
Pellston Airport 10 m Wind Speeds (mph)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2000								5.6	8.1	6.4	7.6	8.0	
2001	8.2	9.5	7.5	9.4	8.3	6.1	7.1	6.7	6.7	9.2	8.8	7.9	7.9
2002	8.9	10.2	9.3	8.9	9.6	6.8	6.1	5.5	6.1	7.0	8.1	8.6	7.9
2003	10.5	8.9	7.9	9.6	8.2	5.9	7.0	5.7	6.9	6.7	8.9	8.4	7.9
2004	9.5	8.0	9.1	9.0	8.2	7.6	5.9	6.5	5.5	8.3			
Average	9.3	9.2	8.5	9.2	8.6	6.6	6.5	6.0	6.7	7.5	8.4	8.2	7.9
11/03-10/04	9.5	8.0	9.1	9.0	8.2	7.6	5.9	6.5	5.5	8.3	8.9	8.4	7.9

Figure 2-9 compares the monthly average airport wind speeds for the monitoring period to the 4-year average. Based on this analysis, it appears that the monitoring period was a relatively normal wind year and therefore a long-term adjustment was not applied to the data sets from the monitoring sites.

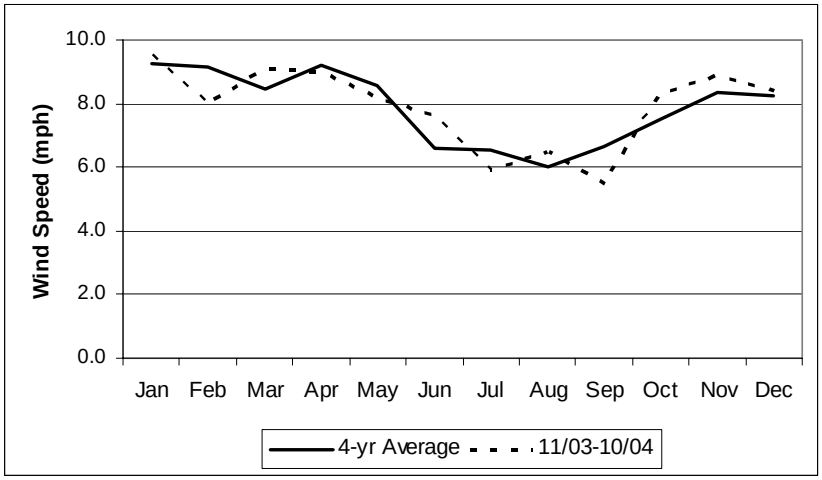

Figure 2-9.
Monthly Airport Wind Speeds (10 m)

The monthly and annual frequency distributions for each of the sites are provided in Table 2-7 though Table 2-11. These frequency distributions are based on wind speeds as measured at the top sensor on each met tower, and have not been normalized for a standard year (i.e., 8760 hours) or for missing data. The normalized hub-height frequency distributions will be presented in Section 3 for the sites selected for further evaluation.

Table 2-7.
40-m Wind Speed Frequency Distribution – Wetmore (Site 8001)

Bin Center	Hours												YTD
(m/s)	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Hours
0.0	0	10	0	0	0	0	0	0	0	0	0	0	10
0.5	12	11	18	25	7	21	12	9	18	6	12	25	176
1.0	16	16	10	24	13	28	15	20	33	26	28	18	247
1.5	23	26	26	27	14	34	20	39	49	40	20	20	338
2.0	49	31	37	39	41	41	28	47	72	46	32	41	504
2.5	55	37	43	40	41	61	52	65	84	69	55	51	653
3.0	65	43	67	49	38	58	44	94	89	58	59	57	721
3.5	71	50	67	67	47	67	67	84	69	85	70	54	798
4.0	93	59	60	77	47	56	79	87	74	91	72	58	853
4.5	49	58	60	54	75	52	60	57	83	75	52	57	732
5.0	41	65	53	81	63	54	65	51	51	59	51	59	693
5.5	45	55	39	52	71	46	48	38	40	48	47	46	575
6.0	26	53	40	44	49	49	45	30	31	42	43	54	506
6.5	37	43	43	30	39	28	57	20	17	43	45	47	449
7.0	27	45	48	33	23	24	39	17	18	22	33	29	358
7.5	23	44	43	20	19	34	37	19	9	12	32	32	324
8.0	24	30	29	11	26	16	21	10	6	7	17	16	213
8.5	18	22	15	6	17	12	17	11	0	6	13	13	150
9.0	10	14	19	6	22	9	13	8	1	3	18	15	138
9.5	6	9	13	6	20	10	12	4	0	2	8	14	104
10.0	6	7	3	4	22	2	9	4	0	1	7	22	87
10.5	1	6	7	0	11	4	4	1	0	2	1	11	48
11.0	2	8	0	1	12	4	0	3	0	0	3	4	37
11.5	5	0	0	0	9	2	0	1	0	1	1	1	20
12.0	7	2	0	0	1	0	0	0	0	0	1	0	11
12.5	2	0	0	0	2	1	0	1	0	0	0	0	6
13.0	1	0	0	0	2	1	0	0	0	0	0	0	4
13.5	0	0	0	0	0	0	0	0	0	0	0	0	0
14.0	2	0	0	0	0	0	0	0	0	0	0	0	2
14.5	2	0	0	0	0	0	0	0	0	0	0	0	2
15.0	1	0	0	0	0	0	0	0	0	0	0	0	1
15.5	1	0	0	0	0	0	0	0	0	0	0	0	1
16.0	0	0	0	0	0	0	0	0	0	0	0	0	0
16.5	0	0	0	0	0	0	0	0	0	0	0	0	0
17.0	0	0	0	0	0	0	0	0	0	0	0	0	0
17.5	0	0	0	0	0	0	0	0	0	0	0	0	0
18.0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.5	0	0	0	0	0	0	0	0	0	0	0	0	0
19.0	0	0	0	0	0	0	0	0	0	0	0	0	0
19.5	0	0	0	0	0	0	0	0	0	0	0	0	0
20.0	0	0	0	0	0	0	0	0	0	0	0	0	0
	720	744	740	696	731	714	744	720	744	744	720	744	8,761

Table 2-8.
40-m Wind Speed Frequency Distribution – Odenaang (Site 8002)

Bin Center	Hours												YTD
(m/s)	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Hours
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.5	7	16	32	38	18	19	9	16	40	17	33	38	283
1.0	17	29	53	27	22	23	8	27	42	22	35	35	340
1.5	29	30	60	54	31	36	36	41	53	39	51	44	504
2.0	52	53	80	55	44	57	43	55	75	53	58	43	668
2.5	67	52	72	60	75	60	69	80	78	69	55	67	804
3.0	44	81	89	49	72	72	75	93	95	91	86	63	910
3.5	64	73	62	72	84	38	79	79	90	93	87	57	878
4.0	62	103	70	59	67	60	85	68	86	83	69	66	878
4.5	54	78	38	66	54	67	93	52	70	58	62	52	744
5.0	60	52	35	43	44	43	81	39	35	52	46	54	584
5.5	47	47	32	47	41	58	34	34	21	40	33	46	480
6.0	44	17	19	33	31	46	44	45	16	44	31	35	405
6.5	42	27	17	25	44	35	36	25	18	23	20	18	330
7.0	27	11	25	17	31	34	23	20	14	25	14	20	261
7.5	22	7	20	12	22	25	8	15	2	10	14	18	175
8.0	24	5	10	14	17	16	7	16	6	9	5	15	144
8.5	13	4	11	5	9	11	4	3	2	2	6	21	91
9.0	14	2	8	6	7	6	2	6	0	0	2	16	69
9.5	9	7	9	6	13	3	4	2	0	5	4	11	73
10.0	5	5	1	1	7	2	3	1	0	2	2	10	39
10.5	7	7	1	3	4	2	1	2	1	2	4	4	38
11.0	4	3	0	0	4	2	0	1	0	1	2	3	20
11.5	2	2	0	4	2	0	0	0	0	2	1	2	15
12.0	1	2	0	0	1	0	0	0	0	2	0	4	10
12.5	0	1	0	0	0	0	0	0	0	0	0	2	3
13.0	1	0	0	0	0	1	0	0	0	0	0	0	2
13.5	1	0	0	0	0	1	0	0	0	0	0	0	2
14.0	1	0	0	0	0	0	0	0	0	0	0	0	1
14.5	0	0	0	0	0	1	0	0	0	0	0	0	1
15.0	0	0	0	0	0	1	0	0	0	0	0	0	1
15.5	0	0	0	0	0	1	0	0	0	0	0	0	1
16.0	0	0	0	0	0	0	0	0	0	0	0	0	0
16.5	0	0	0	0	0	0	0	0	0	0	0	0	0
17.0	0	0	0	0	0	0	0	0	0	0	0	0	0
17.5	0	0	0	0	0	0	0	0	0	0	0	0	0
18.0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.5	0	0	0	0	0	0	0	0	0	0	0	0	0
19.0	0	0	0	0	0	0	0	0	0	0	0	0	0
19.5	0	0	0	0	0	0	0	0	0	0	0	0	0
20.0	0	0	0	0	0	0	0	0	0	0	0	0	0
	720	714	744	696	744	720	744	720	744	744	720	744	8,754

Table 2-9.
40-m Wind Speed Frequency Distribution – St. Ignace (Site 8003)

Bin Center	Hours												YTD
(m/s)	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Hours
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.5	7	12	11	5	8	0	5	8	8	6	1	17	88
1.0	12	7	20	17	9	9	7	20	24	9	8	28	170
1.5	15	10	23	20	7	13	15	25	24	14	29	35	230
2.0	32	12	27	19	14	36	16	35	44	24	43	29	331
2.5	21	21	37	26	23	37	40	45	71	40	57	37	455
3.0	26	25	43	31	43	60	59	60	74	53	69	40	583
3.5	28	45	38	35	47	62	73	68	92	67	69	45	669
4.0	52	47	50	40	52	70	84	54	99	98	51	41	738
4.5	51	71	40	46	55	79	88	56	56	97	83	54	776
5.0	50	86	50	45	46	62	89	63	70	72	72	65	770
5.5	56	88	43	50	61	65	73	60	52	59	58	61	726
6.0	56	67	39	52	68	54	59	60	41	58	46	50	650
6.5	52	50	53	43	56	43	32	53	26	43	26	42	519
7.0	39	53	59	50	32	23	32	32	22	44	30	34	450
7.5	40	52	34	36	32	31	25	16	16	23	14	22	341
8.0	31	27	39	48	31	16	17	12	7	9	20	24	281
8.5	30	16	32	23	20	14	14	12	8	7	5	15	196
9.0	19	15	22	23	16	12	7	8	7	6	7	21	163
9.5	25	15	23	9	23	5	3	6	1	8	18	20	156
10.0	20	4	12	14	16	6	1	6	1	2	1	29	112
10.5	20	7	15	4	23	4	1	9	1	1	5	14	104
11.0	13	5	11	8	16	2	3	6	0	2	3	4	73
11.5	4	4	6	5	3	1	0	6	0	0	3	10	42
12.0	7	1	4	3	6	2	0	0	0	2	2	4	31
12.5	3	2	3	6	7	1	0	0	0	0	0	2	24
13.0	3	0	4	3	1	5	0	0	0	0	0	1	17
13.5	2	1	3	1	0	2	0	0	0	0	0	0	9
14.0	2	0	2	0	1	2	0	0	0	0	0	0	7
14.5	3	1	0	0	1	2	0	0	0	0	0	0	7
15.0	1	0	1	0	0	1	0	0	0	0	0	0	3
15.5	0	0	0	0	0	0	0	0	0	0	0	0	0
16.0	0	0	0	0	0	0	0	0	0	0	0	0	0
16.5	0	0	0	0	0	1	0	0	0	0	0	0	1
17.0	0	0	0	0	0	0	0	0	0	0	0	0	0
17.5	0	0	0	0	0	0	0	0	0	0	0	0	0
18.0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.5	0	0	0	0	0	0	0	0	0	0	0	0	0
19.0	0	0	0	0	0	0	0	0	0	0	0	0	0
19.5	0	0	0	0	0	0	0	0	0	0	0	0	0
20.0	0	0	0	0	0	0	0	0	0	0	0	0	0
	720	744	744	662	717	720	743	720	744	744	720	744	8,722

Table 2-10.
40-m Wind Speed Frequency Distribution – Manistique (Site 8004)

Bin Center	Hours												YTD
(m/s)	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Hours
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.5	4	10	7	11	7	2	9	10	4	4	6	8	82
1.0	11	9	9	13	10	11	13	10	5	9	12	14	126
1.5	11	17	18	13	14	15	18	29	11	7	11	16	180
2.0	22	22	26	22	26	18	36	45	17	19	18	25	296
2.5	35	44	31	15	38	35	36	47	28	29	30	39	407
3.0	39	56	56	44	41	33	48	59	37	60	67	51	591
3.5	59	60	57	52	67	47	68	82	69	80	53	58	752
4.0	65	63	67	64	54	63	80	86	93	90	58	65	848
4.5	63	54	50	67	85	82	79	92	118	83	53	82	908
5.0	55	53	58	60	55	71	93	82	81	86	70	97	861
5.5	53	66	59	52	70	77	56	74	100	59	59	55	780
6.0	57	60	45	53	55	71	57	42	64	53	58	61	676
6.5	47	46	44	51	52	65	44	34	34	40	54	32	543
7.0	53	52	26	47	40	36	27	9	30	29	39	37	425
7.5	41	34	26	43	28	24	14	18	30	27	35	23	343
8.0	42	39	30	32	23	31	19	5	12	13	28	17	291
8.5	27	28	14	31	10	29	9	3	8	10	19	13	201
9.0	16	15	9	13	5	16	6	6	0	5	19	6	116
9.5	16	8	6	16	4	10	4	3	1	7	10	7	92
10.0	10	2	10	15	4	6	3	6	2	3	11	4	76
10.5	8	4	3	10	4	2	1	2	0	2	18	2	56
11.0	4	0	3	8	3	0	0	0	0	2	9	2	31
11.5	3	1	2	4	7	0	0	0	0	1	3	3	24
12.0	1	0	1	1	4	0	0	0	0	0	1	2	10
12.5	2	1	0	1	2	0	0	0	0	1	0	1	8
13.0	0	0	0	1	1	0	0	0	0	0	3	0	5
13.5	0	0	0	2	0	0	0	0	0	0	0	0	2
14.0	0	0	0	3	0	0	0	0	0	1	0	0	4
14.5	0	0	0	0	0	0	0	0	0	0	0	0	0
15.0	0	0	0	0	0	0	0	0	0	0	0	0	0
15.5	0	0	0	0	0	0	0	0	0	0	0	0	0
16.0	0	0	0	0	0	0	0	0	0	0	0	0	0
16.5	0	0	0	0	0	0	0	0	0	0	0	0	0
17.0	0	0	0	0	0	0	0	0	0	0	0	0	0
17.5	0	0	0	0	0	0	0	0	0	0	0	0	0
18.0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.5	0	0	0	0	0	0	0	0	0	0	0	0	0
19.0	0	0	0	0	0	0	0	0	0	0	0	0	0
19.5	0	0	0	0	0	0	0	0	0	0	0	0	0
20.0	0	0	0	0	0	0	0	0	0	0	0	0	0
	744	744	657	744	709	744	720	744	744	720	744	720	8,734

Table 2-11.
30-m Wind Speed Frequency Distribution – Newberry (Site 8005)

Bin Center (m/s)	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	YTD Hours
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.5	12	37	19	14	11	5	11	29	9	15	24	33	219
1.0	22	41	22	15	26	13	24	39	10	21	28	23	284
1.5	33	52	38	25	46	14	37	55	29	25	38	35	427
2.0	54	66	49	28	49	31	61	61	49	46	40	47	581
2.5	64	80	82	70	73	55	87	92	73	68	81	55	880
3.0	70	49	59	90	79	86	105	96	104	81	78	57	954
3.5	86	58	64	81	56	94	86	115	116	91	81	73	1001
4.0	70	53	54	62	48	91	52	81	94	82	70	84	841
4.5	67	54	62	59	61	76	57	57	74	74	56	79	776
5.0	49	62	66	51	51	80	51	40	55	60	43	68	676
5.5	49	49	67	45	70	56	34	27	43	51	36	59	586
6.0	37	54	39	50	46	28	28	13	21	30	39	40	425
6.5	17	31	14	31	35	37	21	15	21	25	37	27	311
7.0	24	23	20	38	28	23	22	9	21	26	28	16	278
7.5	12	19	15	29	7	15	14	12	13	12	19	14	181
8.0	5	5	5	21	15	6	11	3	5	6	21	3	106
8.5	4	6	7	14	10	6	8	0	3	4	10	2	74
9.0	5	5	6	7	4	5	9	0	3	2	6	4	56
9.5	1	0	5	7	3	5	2	0	1	0	5	1	30
10.0	2	0	1	3	2	3	0	0	0	0	3	0	14
10.5	0	0	1	1	0	1	0	0	0	1	1	0	5
11.0	0	0	0	1	0	4	0	0	0	0	0	0	5
11.5	0	0	1	1	0	3	0	0	0	0	0	0	5
12.0	0	0	0	1	0	5	0	0	0	0	0	0	6
12.5	0	0	0	0	0	1	0	0	0	0	0	0	1
13.0	0	0	0	0	0	0	0	0	0	0	0	0	0
13.5	0	0	0	0	0	0	0	0	0	0	0	0	0
14.0	0	0	0	0	0	0	0	0	0	0	0	0	0
14.5	0	0	0	0	0	0	0	0	0	0	0	0	0
15.0	0	0	0	0	0	0	0	0	0	0	0	0	0
15.5	0	0	0	0	0	0	0	0	0	0	0	0	0
16.0	0	0	0	0	0	0	0	0	0	0	0	0	0
16.5	0	0	0	0	0	0	0	0	0	0	0	0	0
17.0	0	0	0	0	0	0	0	0	0	0	0	0	0
17.5	0	0	0	0	0	0	0	0	0	0	0	0	0
18.0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.5	0	0	0	0	0	0	0	0	0	0	0	0	0
19.0	0	0	0	0	0	0	0	0	0	0	0	0	0
19.5	0	0	0	0	0	0	0	0	0	0	0	0	0
20.0	0	0	0	0	0	0	0	0	0	0	0	0	0
	683	744	696	744	720	743	720	744	744	720	744	720	8,722

Wind Direction

Figure 2-10 illustrates the annual wind direction at each of the five sites. The graphs consist of two bars in each of the 16 wind direction sectors that represent the percent of total time and the percent of total wind energy. As shown in the graphs, the predominant energy-producing winds during the year varied from site to site. Only the Wetmore and Manistique sites show a strong bi-directional pattern, and even these sites have energy components from all directions. The other sites are more omni-directional. The wind roses exemplify the influences of Lake Huron, Lake Michigan, and Lake Superior on the wind resource in the eastern UP.

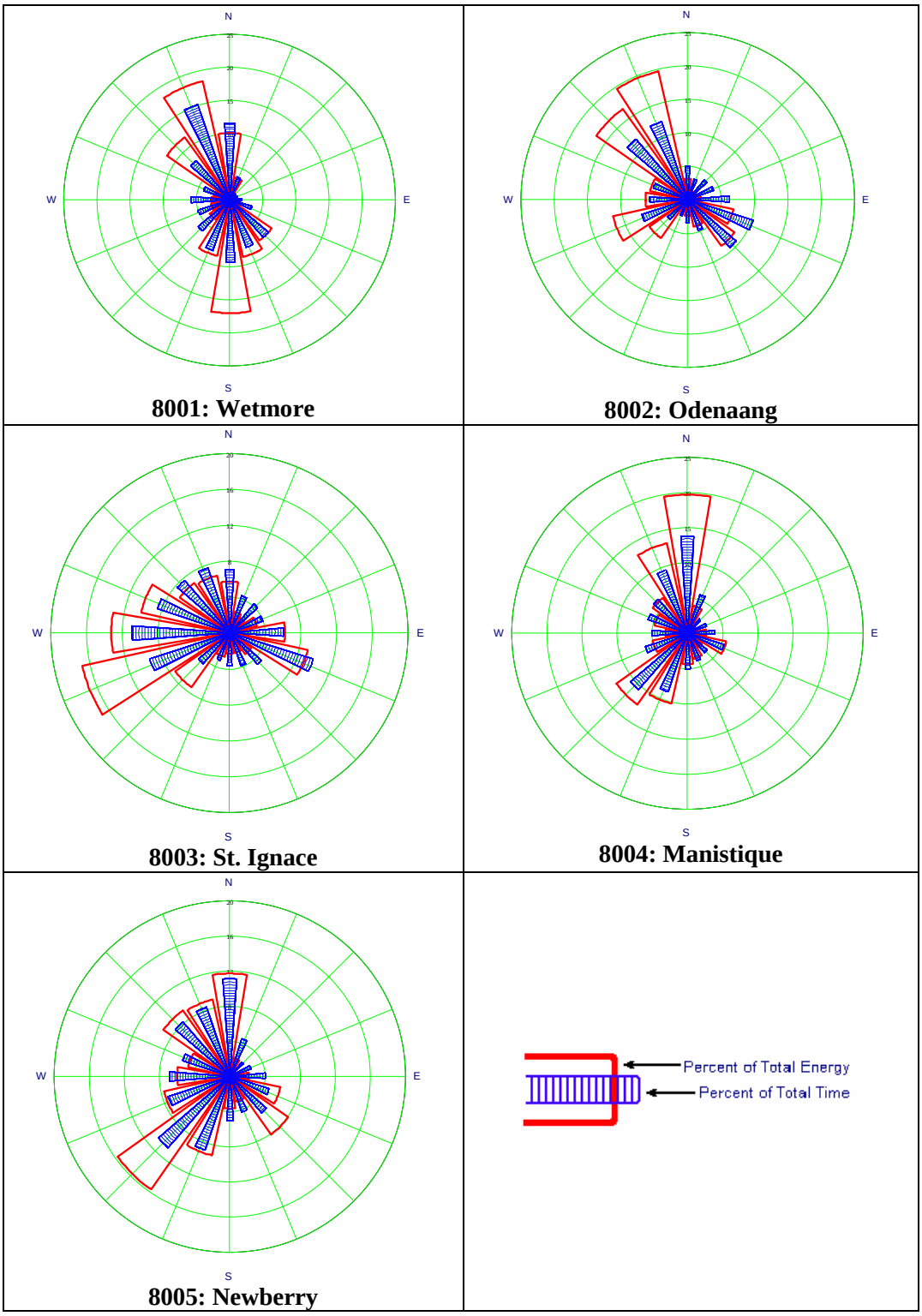

Figure 2-10.
Annual Wind Roses for the Five Sites

2.3.4 Diurnal Wind Analysis

Figure 2-11 illustrates the diurnal pattern of the winds for each of the monitoring sites. As seen in the figure, the sites experienced a very similar diurnal pattern. The winds tend to be the highest during the afternoon and lowest during early morning. While the average velocity of the winds may vary from year to year, the diurnal shape of the winds tends be similar each year.

Although not shown, GEC also reviewed the diurnal pattern of the winds by month. Based on our review, it appears that the diurnal shapes of the wind are similar throughout the year.

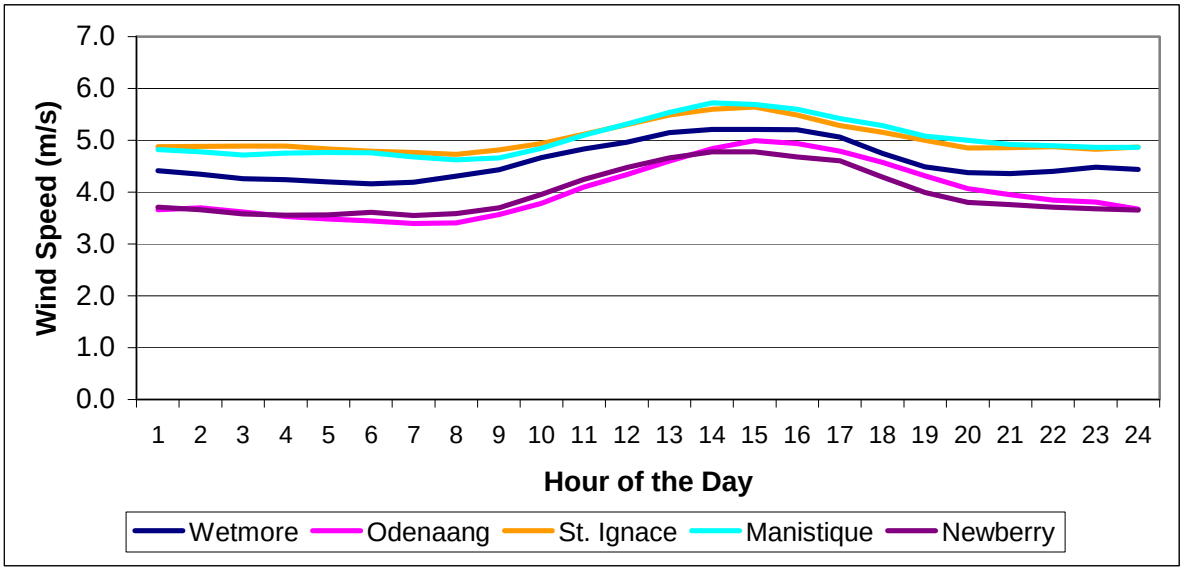

Figure 2-11.
Annual Diurnal Wind Speeds

2.3.5 Wind Shear

Monthly wind shear exponent values are provided in Table 2-12. The wind shear exponent represents the degree to which wind speed increases with height. For the purposes of this report, the wind shear exponent was calculated for the 20- to 40-m height at Wetmore, Odenaang, and Manistique, from the 10- to 30-m height at Newberry, and the 30- to 50-m height at St. Ignace. The theoretically derived value for wind shear over smooth, flat terrain is 0.14. During wind farm development, wind shear is used when determining an appropriate wind turbine hub height. The calculated shear values shown Table 2-12 are unrealistically high and likely indicate some obstruction or sensor slow down at the lower sensor levels due to terrain roughness (i.e., vegetation).

In addition to a monthly variation, wind shear varies at different wind speeds, during different times of the year, and during different times of the day. Throughout the central regions of the United States, the wind shear tends to vary quite significantly from day to night. Figure 2-12 illustrates the variation of the wind shear throughout the day. While the actual calculated wind shear may be overestimated, the pattern of high wind shear at night and low wind shear during the day is accurate.

Table 2-12.
Monthly Wind Shear Exponent

	Site Number and Location				
	8001 Wetmore	**8002 Odenaang**	**8003 St. Ignace**	**8004 Manistique**	**8005 Newberry**
	20-40 m	**20-40 m**	**30-50 m**	**20-40 m**	**10-30 m**
January	0.413	0.459	0.342	0.297	0.325
February	0.367	0.362	0.403	0.353	0.333
March	0.383	0.424	0.475	0.315	0.302
April	0.372	0.442	0.470	0.246	0.273
May	0.340	0.397	0.385	0.252	0.258
June	0.355	0.338	0.407	0.221	0.258
July	0.373	0.373	0.370	0.220	0.295
August	0.387	0.370	0.363	0.229	0.265
September	0.362	0.314	0.401	0.244	0.272
October	0.388	0.341	0.437	0.275	0.274
November	0.353	0.437	0.383	0.292	0.265
December	0.386	0.475	0.422	0.316	0.316
Annual	0.375	0.396	0.403	0.278	0.296

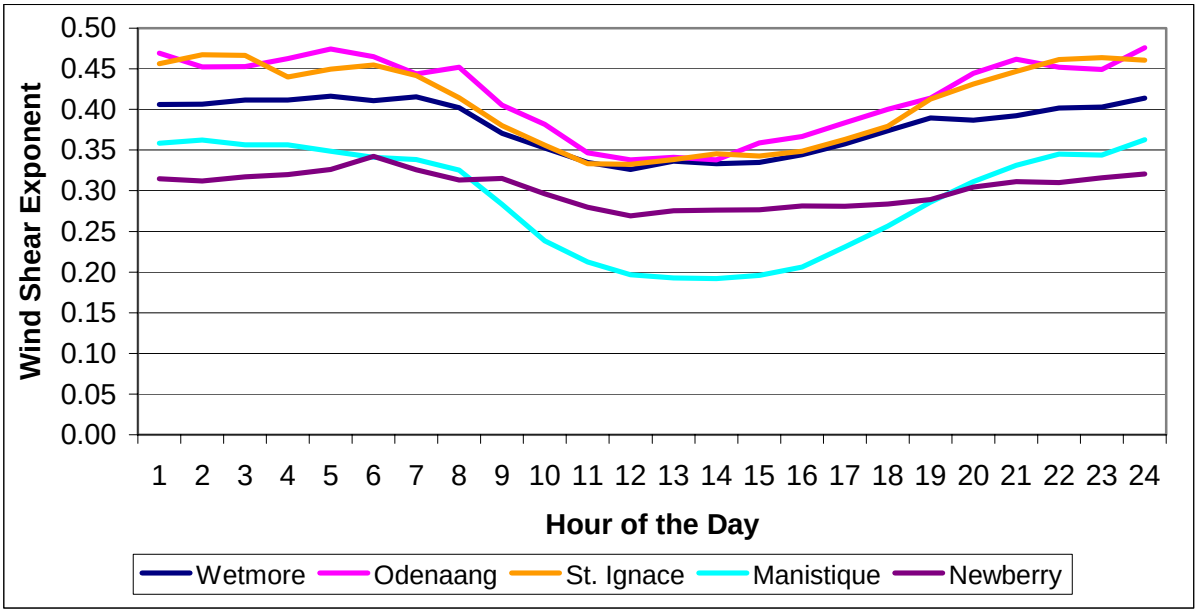

Figure 2-12.
Annual Diurnal Wind Shear

2.3.6 Turbulence Intensity

Turbulence intensity (TI) is a relative indicator of turbulence and not an absolute value. The average turbulence intensity at the upper monitoring level at the two most developable sites, St. Ignace and Manistique, is summarized in Table 2-13. IEC wind turbine design standards specify a turbine to be designed for TI levels up to 0.18 in 15 m/s winds. The TI values shown in the table are calculated in winds greater than 4 m/s. The TI values shown indicate a relatively

turbulent wind resource. GEC recommends that TI be discussed with the manufacturers of the proposed wind turbines.

Table 2-13.
Monthly Turbulence Intensity

	St. Ignace	Manistique
Jan	0.161	0.187
Feb	0.150	0.183
Mar	0.161	0.176
Apr	0.161	0.174
May	0.169	0.183
Jun	0.160	0.172
Jul	0.154	0.165
Aug	0.147	0.166
Sep	0.141	0.166
Oct	0.161	0.182
Nov	0.166	0.182
Dec	0.157	0.172
Annual	0.157	0.176

2.4 Recommendations for Moving Forward with the Selected Sites

2.4.1 Wetmore in Alger County (8001)

A 40-m tower is installed at the Wetmore site. The average wind speed is under 5 m/s at 40 m. The wooded area just west of the housing development may be available for installation of a wind turbine. However, the houses are individually metered. Converting the individual meters to a single meter for the housing complex requires significant capital and a willingness on the Tribe's part to become an owner/operator of distribution lines. The only tribally owned structure is a maintenance building just north of the housing development. Though the electrical load at the maintenance building is not known, it is probably not enough to justify a small-scale turbine.

GEC recommends that this site not be pursued further at this time due to the low wind speeds and the probable low electrical load at the maintenance building. GEC also recommends decommissioning the tower at this site.

2.4.2 Odenaang in Chippewa County (8002)

A 40-m tower is installed at the Odenaang site. The average wind speed is approximately 4 m/s at 40 m. The site has approximately 300 acres that may be available for wind energy development. However, the wind speeds do not support the installation of large-scale turbines. The distance between the site and the load centers of the casino and health center make the installation of small-scale turbines prohibitively expensive. Though tribal houses are located nearby, they are individually metered.

GEC recommends that this site not be pursued further at this time due to the low winds speeds, which are the lowest of the five sites measured. GEC also recommends decommissioning the tower at this site.

2.4.3 St. Ignace in Mackinac County (8003)

A 50-m tower is installed at the St. Ignace site. Wind speeds at 40 m are approximately 5 m/s while winds at 50 m average 5.4 m/s. St. Ignace has one of the highest measured wind speeds of the sites monitored. The St. Ignace Casino is expanding but GEC has not received a copy of the footprint and coordinates of the new building. Given the location of the met tower on Rabbit Back Hill, it is likely that room still remains for a wind turbine at this site. The site is approximately 2 miles from the Mackinac County Airport. FAA approval was not obtained for the met tower but may be necessary for a wind turbine.

Based on the site wind speeds and proximity to load, GEC recommends evaluating the economics of installing a small-scale turbine. Although a full year's worth of data has been collected, the met tower sensor should continue collecting data until the Tribe installs a wind turbine at the site or chooses to not pursue installing a wind turbine at St. Ignace.

2.4.4 Manistique in Schoolcraft County (8004)

The Manistique site also has a 40-m met tower. At the 40-m level, wind speeds at Manistique were similar to those at St. Ignace. Tribal land may be available just north of the casino and health center; however, the closer proximity to the Schoolcraft County Airport may restrict the height of a wind turbine. A turbine in this location could reduce the electrical needs of the health center.

Based on the wind speeds and the local load, GEC recommends evaluating the economics of installing a small-scale turbine. Although a full year's worth of data has been collected, the met tower sensor should continue collecting data until the Tribe installs a wind turbine at the site or chooses to not pursue installing a wind turbine at Manistique.

2.4.5 Newberry in Luce County (8005)

The Newberry site has the shortest met tower installed at only 30 m. The average wind speed at this height is approximately 4 m/s, which is lower than the 30-m measured wind speeds at St. Ignace and Manistique. The available land north of the community/health center and south of M-28 would accommodate one small-scale wind turbine. The site is also located near the Luce County Airport.

GEC recommends not pursing this location at this time. The combination of the wind speed and proximity to the airport make installing a wind turbine here much less viable. GEC also recommends decommissioning the met tower.

Section 3 - Conceptual Design and Energy Estimate

Given the low wind resource at St. Ignace and Manistique, GEC evaluated two options for small-scale turbines at these two sites. For the evaluation, GEC chose Bergey Windpower Company's 10 kW BWC Excel-S (Bergey) turbine and Entegrity Wind Systems' EW15 turbine, which produces 50 kW at 11.3 m/s (25 mph) and has a maximum output of 66 kW. The capacity of these turbines is lower than the typical monthly demand experienced at the St. Ignace casino and Manistique health center; therefore, the turbines will most likely only offset site load. The Tribe did not provide utility bills, so the load profile and min/max demand at these two sites is not known to GEC. The turbines do not provide backup power for when the electric grid is down.

3.1 Conceptual Design

3.1.1 Conceptual Layout

Figure 3-1 and Figure 3-2 show the placement of the turbine at the current met tower location surrounded by a proposed setback equal to the maximum tip height (MaxTH). The proposed setback is based on draft guidelines for siting wind energy systems develop by Michigan's Energy Office. For systems sized at 300 kW or less, the setback from property lines needs to be at least equal to the MaxTH. Exceptions can be granted by the neighboring property owners. The minimum tip clearance (MinTC) must be at least 20 ft (6 m) above grade. Table 3-1 presents the calculation of the MaxTH and MinTC for both turbines. The MinTC for both turbines is well within the guidelines' limit.

Table 3-1.
MaxTH and MinTC

	Bergey	EW15
Hub Height	120 ft (36.6 m)	120 ft (36.6 m)
Rotor Diameter	23 ft (7 m)	49.2 ft (15 m)
MaxTH	131.5 ft (40 m)	144.6 ft (44 m)
MinTC	108.2 ft (33 m)	95.4 ft (29 m)

GEC proposes to locate the St. Ignace turbine at the same location as the met tower. The met tower can be decommissioned before the turbine is installed. This location optimizes the capture of winds accelerating over Rabbit Back Hill.

This location is approximately 1,000 ft to the southeast of the existing casino as shown in Figure 3-1. The location with respect to the casino expansion is not known because the Tribe did not provide a location for the casino expansion. Given that the met tower is still operational, it appears that this location would still be acceptable for a wind turbine. However, if either the new casino or parking lot falls within the proposed setback, then the turbine location could be adjusted accordingly.

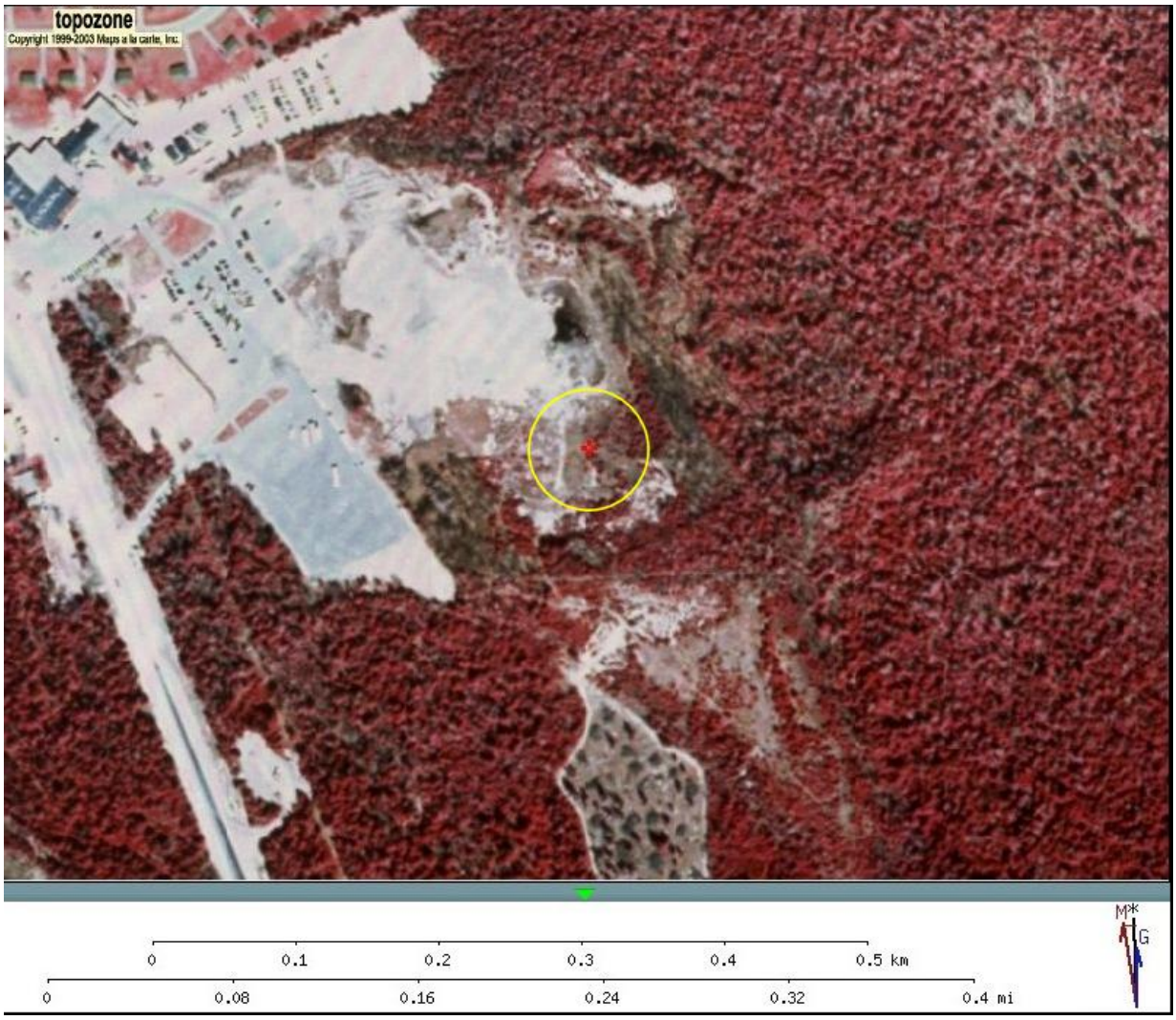

Figure 3-1.
Conceptual Layout for One Small Wind Turbine at St. Ignace Casino

GEC proposes to locate the Manistique turbine at the same location as the met tower, as shown in Figure 3-2. The met tower can be decommissioned before the turbine is installed. This location is between the health center and casino, approximately 320 ft west of the casino. The figure shows that sufficient space exists between the casino and health center parking lots for either wind turbine.

Figure 3-2.
Conceptual Layout for One Small Wind Turbine at Manistique Health Center

3.1.2 Interconnection Configuration

Figure 3-3 shows the basic configuration for a small wind turbine system used for distributed generation. The only difference between the Bergey and the EW15 for this schematic is the inverter. The Bergey requires the inverter to convert the direct current (DC) power generated by the wind turbine into alternating current (AC). The EW15 generates AC power.

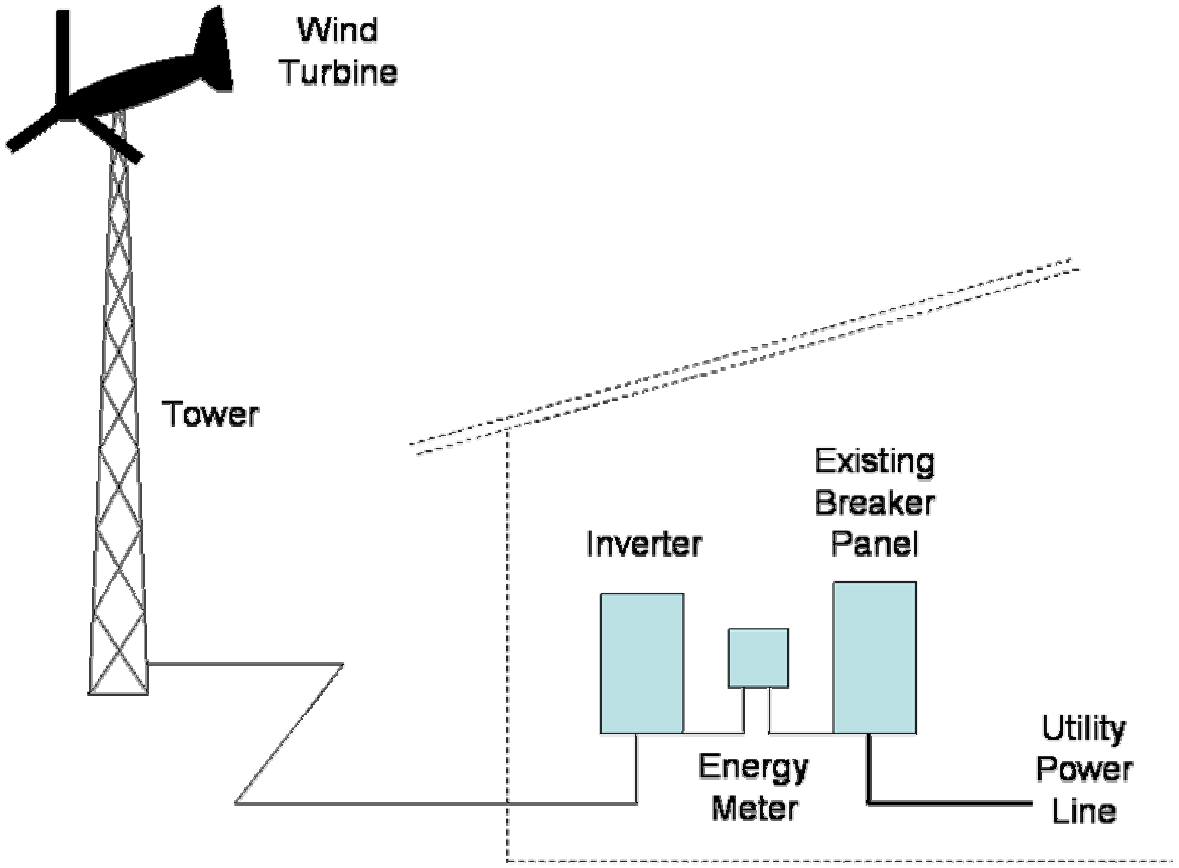

Figure 3-3.
Small-scale Wind Turbine Interconnection Diagram

For the Bergey, representatives of Edison Sault Electric (Edison Sault) said that no special disconnect or protection electrical equipment would be needed to incorporate the wind turbine since the representative believes that the electrical panel at the casino and at the health center are such that in the event of a loss of power, the breakers would trip and keep utility workers fixing the grid safe from any potential back flow of energy from the Bergey.

However, if the EW15 is installed, Edison Sault would require the Tribe to submit a formal request following the *Michigan Utility Interconnection Procedures for Projects with Aggregate Generator Output of 30 kW or More, but Less than 150 kW*. The EW15 would likely require new metering, relays, and disconnects.

3.2 Energy Estimate

Energy production is a function of the turbine's power curve and the wind resource characteristics at the location. The power curve defines the gross power that a given turbine can produce at various wind speeds and air densities. GEC utilized the manufacturer's published power curves for the Bergey and EW15 turbines, adjusted to estimated site air density. Integrating the site's measured wind speed frequency distribution of hub-height wind speed with the turbine's air-density-adjusted power curve yields a per turbine gross annual energy production. Table 3-2 presents the hub-height normalized frequency distributions at St. Ignace and Manistique.

Table 3-2.
Normalized Hub Height Frequency Distributions

Wind Speed Bin (m/s)	St Ignace Hours	Manistique Hours	Wind Speed Bin (m/s)	St Ignace Hours	Manistique Hours
0.0	0	0	10.5	59	44
0.5	67	82	11.0	42	38
1.0	161	126	11.5	36	17
1.5	253	181	12.0	16	7
2.0	387	326	12.5	11	6
2.5	560	440	13.0	10	3
3.0	645	667	13.5	4	2
3.5	768	766	14.0	1	3
4.0	785	895	14.5	2	0
4.5	828	913	15.0	0	0
5.0	820	851	15.5	0	0
5.5	744	757	16.0	0	0
6.0	607	654	16.5	1	0
6.5	504	531	17.0	0	0
7.0	401	393	17.5	0	0
7.5	292	352	18.0	0	0
8.0	210	271	18.5	0	0
8.5	175	177	19.0	0	0
9.0	158	104	19.5	0	0
9.5	116	91	20.0	0	0
10.0	96	63		8760	8760

The net turbine generation is calculated by applying energy losses to the gross turbine production. Table 3-3 depicts the assumed energy losses for the Bergey and EW15 turbines. The Bergey has fewer line-item losses because the manufacturer's power curve measures output after the inverter. Therefore, the power curve accounts for losses associated with electrical lines and controls. Availability losses encompass scheduled and unscheduled maintenance, other turbine events, and collection system or grid outages. Electrical losses include losses caused by the transmission distance between the turbines and the electric collection point (e.g., inverter). Control system/power curve losses account for times when the automated operation of the turbine lags frequent changes in the wind speed or direction, causing the turbine's performance to differ from the manufacturer's power curve. Blade soiling occurs with the accumulation of dirt and insects, which affects the aerodynamics of the blades, lowering production. The types of

weather-related losses may include icing, and shutdowns to avoid hail, lightning, or other storm damage.

Table 3-3.
Estimated Energy Losses

	Bergey		EW15	
Loss Factors	**Estimated Loss**	**Cumulative Losses**	**Estimated Loss**	**Cumulative Losses**
Availability	5.0%	5.0%	5.0%	5.0%
Electrical	NA	5.0%	1.5%	6.4%
Control System/Power Curve	NA	5.0%	2.0%	8.3%
Blade Soiling	1.5%	6.4%	1.5%	9.7%
Weather	2.0%	8.3%	2.0%	11.5%

Table 3-4 shows the estimated long-term annual average hub-height wind speed for the sites, the estimated annual gross project energy, and the estimated annual net project energy. Even though the average annual hub-height wind speed is similar at the two sites, differences in the frequency distribution result in differences in the estimated turbine production.

Table 3-4.
Energy Estimates

	St. Ignace		Manistique	
Hub-Height Average Wind Speed (m/s)	4.9		4.9	
Site Elevation (m)	194		208	
Turbine	Bergey	EW15	Bergey	EW15
Gross Energy (kWh/yr)	9,300	57,400	8,700	53,500
Net Energy (kWh/yr)	8,500	50,800	8,000	47,400

Section 4 - Market for Energy and Credits

According to Edison Sault, the proposed turbines' capacities are lower than the demand at the St. Ignace Casino and Manistique Health Center, resulting in little-to-no excess energy available for sale to the utility. However, demand may drop below 66 kW, potentially making excess energy available for sale. Therefore, this section provides an overview of how any excess energy could be sold to the local utility, Edison Sault. Since large-scale turbines were not used in this analysis, discussion of direct sale to the utility as an independent power producer is not included.

4.1 PURPA

The Public Utilities Regulatory Policy Act (PURPA) requires utilities to accept energy from qualifying facilities such as renewable energy generators. Under this arrangement, Edison Sault would purchase the excess energy delivered by the Tribe's wind generator at Edison Sault's avoided cost of energy. This avoided cost is in the 2-3 ¢/kWh range, which is less than the price paid by the Tribe for the energy supplied by Edison Sault. Since the retail sales price and avoided cost differ, Edison Sault would most likely require a second meter at the site to record how much energy is delivered to the grid. The cost of the additional meter can be prohibitive of selling energy back to the utility under PURPA, particularly for small systems.

4.2 Net Metering

Net metering differs from PURPA sales in that the customer, in essence, receives the retail price for the excess energy they deliver to the grid. The customer's meter runs backward when excess energy is generated, resulting in a net-energy-consumed meter reading each month. The net meter reading accounts for all energy consumed from the grid less all energy delivered to the grid. For billing purposes, this makes the excess energy worth the same as the utility-supplied energy. If the self-generator delivers more energy than it uses from the grid in a billing period, the net excess generation (NEG) is either donated to the utility or banked against the next billing period's usage.

On March 29, 2005, the Michigan Pubic Service Commission (MPSC) announced the implementation of a statewide net metering program. The consensus[4] on a net metering program in Michigan includes the following provisions:

- Program limit of the greater of 100 kW or 0.1% of the utility's previous year's peak demand. A utility can voluntarily expand beyond this limit.
- Maximum system size of 30 kW. A utility could voluntarily increase to less than 150 kW.
- Systems should be limited in size by the customer's self-service needs (capacity or annual consumption).
- Eligible systems are limited to renewable energy systems. A utility could petition to expand program to include high-efficiency energy conversion technologies.
- NEG may be carried forward to the next billing period with a limit at a 12-month billing period. Any NEG remaining at the end of the 12-month period is donated to the utility.

[4] *MREP Consensus Agreement on Statewide Net Metering Program,* December 2, 2004. Case No. U-14346.

- Open enrollment for 5 years.
- Participation limit is 10 years.
- Renewable energy certificates[5] (RECs).
  - If the customer participates in net metering, the utility owns all the RECs.
  - If the customer delivers excess energy under a distributed generation tariff or through a power purchase agreement, then the utility owns the RECs associated with the excess energy while the customer retains ownership of RECs associated with energy generated and consumed on-site.
- A utility may opt to sell their RECs. Proceeds offset the operating costs of the net metering program. Any remaining proceeds will be split 50/50 between the utility and the net metering customers on a pro-rata basis.

Under this pilot net metering program, only the 10 kW Bergey would automatically be eligible for net metering. Given the difference between the load at the two sites and the turbine size, it is very unlikely that the Tribe would have any excess energy to sell to the utility.

If the EW15 is installed, the Tribe could petition Edison Sault to see if they would allow the larger machine in the net metering program, or sell to the utility under PURPA, a power purchase agreement, or a distributed generation tariff if Edison Sault creates one as a result of the net metering process and new interconnection standards. If the EW15 is economically feasible, the Tribe should determine the possibility of having excess energy to sell based on the load profile at the St. Ignace casino or Manistique health center and the diurnal wind pattern at the site.

4.3 Renewable Energy Credit Programs

Of the active retail marketers of RECs[6], Mainstay Energy is the only one to actively promote themselves as an aggregator of small-scale renewable energy. They aggregate the RECs available from eligible small-scale renewable energy generation so that the aggregate can be sold on the market. Eligible generators must register in the Mainstay Energy and Efficiency Tracking database. According to information on the website, the May 2005 market price for RECs from wind energy was 0.5 ¢/kWh[7]. Therefore, for a project that generates 50,000 kWh/yr, the annual revenue from selling the RECs would be $250. Since this amount is small compared to the economics of small-scale wind generation, sales from RECs will not be considered further.

[5] Renewable energy credits (RECs) represent the environmental attributes associated with electricity generation from renewable technologies like wind and solar energy.
[6] As listed on the U.S. Department of Energy's Energy Efficiency and Renewable Energy website, April 18, 2005, <http://www.eere.energy.gov/greenpower/markets/certificates.shtml?page=2> accessed June 30, 2005.
[7] Mainstay Energy Michigan Rewards Webpage May 17, 2005, <http://mainstayenergy.com/rewardsmap/mi.php> accessed June 30, 2005.

Section 5 - Identification of Potential Environmental Issues

In the spring of 2004, GEC conducted a preliminary environmental assessment (EA). This assessment, located in Appendix B, identified threatened and endangered species in each county, as well as historical bridges, some scenic improvement projects, and the location of national parks/forests. The numerous lakes and rivers in the counties increase the chance that one or more of the sites may be in a sensitive watershed. The remainder of this section focuses on the two potential sites: St. Ignace in Mackinac County and Manistique in Schoolcraft County.

5.1 Threatened and Endangered Species in the Two Counties

The information presented in this section comes from the following sources:

- U.S. Fish & Wildlife Service. *County Distribution of Michigan's Federally-Listed Threatened, Endangered, Proposed, and Candidate Species*. November 2004.
- U.S. Fish & Wildlife Service. Critical Habitat web pages, by species (e.g. piping plover http://www.fws.gov/plover/)
- U.S. Fish & Wildlife Service. Threatened and Endangered species web pages, by species (e.g. bald eagle http://www.fws.gov/endangered/i/b0h.html)
- Michigan Department of Natural Resources webpage http://www.michigan.gov/dnr/0,1607,7-153-10370_12144---,00.html
- National Wildlife Federation. American Bald Eagle webpage. http://www.nwf.org/wildlife/baldeagle/

5.1.1 Wildlife

Table 5-1 presents a list of the U.S. federally listed endangered, threatened, and candidate wildlife species that do or may occur in the two counties.

Table 5-1.
Federally Listed Endangered, Threatened, and Candidate Species: Wildlife

County	Status	Species	Habitat
Mackinac & Schoolcraft	Endangered/Critical Habitat Designated	Piping Plover	Beaches along shorelines
	Threatened	Bald Eagle	Mature forest near water
	Threatened	Canada Lynx	One lynx was recently documented in the UP
	Threatened	Gray Wolf	Northern forested areas
Mackinac	Endangered	Hine's Emerald Dragonfly	Spring-fed wetlands, wet meadows and marshes, calcareous streams, and associated wetland overlying dolomite bedrock
	Candidate	Eastern Massasauga Rattlesnake	
Schoolcraft	Endangered	Kirtland's Warbler	Nests in young stands of jack pine

Source: U.S. Fish & Wildlife Service. *County Distribution of Michigan's Federally-Listed Threatened, Endangered, Proposed, and Candidate Species*. November 2004.

Piping Plover: The piping plover is found on beaches and makes its nest by creating a shallow depression in the sand. The critical habitat extends 500 m from the normal high water mark. The St. Ignace site may be at the very edge of this limit; however, the site is elevated above the beach and is characterized more by woodland than sandy beach. The Manistique site is approximately 1,500 m from the lake, and should be outside the buffer. Given the nesting pattern, location of the projects, and heavy construction at both sites, it is unlikely that either project would adversely impact the piping plover population.

Bald Eagle: Bald eagles typically nest at the tops of tall trees and avoid developed areas. However, Michigan has numerous wildlife viewing areas. Horseshoe Bay is approximately one mile north of the proposed St. Ignace site, and according to the DNR bald eagles have occasionally been spotted in the tree tops. The Rainey Wildlife Area is approximately 7 miles from the Manistique site while the Seney National Wildlife Refuge is approximately 13 miles away. Though these viewing areas are probably far enough away from Manistique, the proximity of Horseshoe Bay to St. Ignace may increase the chance of a flight path near the proposed turbine location. The Tribe should investigate this possibility further if they choose to install a turbine at St. Ignace.

Canada Lynx: One Canada Lynx was caught in a foothold trap in Mackinac County on forest service property in November 2003. The U.S. Fish & Wildlife Service (USF&WS) believes this to be a lone lynx, not part of an established group. When populations increase in Canada, some lynx roam farther than normal, usually into Minnesota. According to the USF&WS, both Mackinac and Schoolcraft counties could potentially sustain the Canada Lynx. Given the infrequency in which these lynx are seen in the UP, it is unlikely that the proposed projects would adversely impact the Canada Lynx.

Gray Wolf: Gray wolves are seen throughout Michigan and the Michigan Department of Natural Resources (DNR) does frequent wolf tracking. Given the location of these turbines in developed areas, the threat to gray wolf habitat is minimal.

Hine's Emerald Dragonfly: This particular dragonfly's only Michigan habitat is located in the Hiawatha National Forest. The eastern section of this forest covers parts of Mackinac and Chippewa counties. This dragonfly's habitat comprises cool, shallow, slow moving water, spring-fed marshes, or seepage sedge meadows. It is unlikely that construction and operation of a small wind turbine at St. Ignace would adversely impact the Hine's Emerald Dragonfly since the proposed site is in a developed area.

Eastern Massasauga Rattlesnake: This snake is listed as a candidate species on the federal list. It is also listed as a species of special concern by the Michigan DNR. According to the DNR, this snake is *not* found in the UP. Given the casino construction at St. Ignace it is unlikely that the development of a wind turbine in the same area would adversely impact the potential existence of this rattlesnake in St. Ignace.

Kirtland's Warbler: Kirtland's Warbler is found in a few counties in Michigan, with the largest populations located in Lower Michigan. It nests in vegetation in jack pine stands; preferably over 80 acres in size. As of 1999, only a few singing males were identified in Schoolcraft county.

However, the 2001 census of the bird showed the largest overall population to date. This may indicate that the population in Schoolcraft County is also growing. The Manistique site is in a developed location, so impact to the warbler should be minimal.

5.1.2 Plants

Table 5-2 presents a list of the U.S. federally listed endangered, threatened, and candidate plant species that do or may occur in the two counties.

Table 5-2.
Federally Listed Endangered, Threatened, and Candidate Species: Plant

County	Status	Species	Habitat
Mackinac & Schoolcraft	Threatened	Dwarf Lake Iris	Partially shaded sandy-gravelly soils on lakeshores
	Threatened	Houghton's Goldenrod	Sandy flats along Great Lakes shores
	Threatened	Pitcher's Thistle	Stabilized dunes and blowout areas
Mackinac	Endangered	Michigan Monkey Flower	Soils saturated with cold flowing spring water; found along seepages, streams, and lakeshores
	Threatened	American Hart's Tongue	Cool limestone sinkholes in mature hardwood forest
	Threatened	Lakeside Daisy	Dry gravelly or sandy thin-soiled fields and alvars with dolomitic or limestone bedrock at or near the surface

Source: U.S. Fish & Wildlife Service. *County Distribution of Michigan's Federally-Listed Threatened, Endangered, Proposed, and Candidate Species*. November 2004.

Dwarf Lake Iris: This iris only grows in the Great Lakes region. Its typical habitat includes shoreline or sand on thin soil over limestone-rich gravel or bedrock. It is also found along old beach ridges of former Great Lakes shores. Given the distance from the shoreline of the two proposed sites, impact to the Dwarf Lake Iris is unlikely during the construction and operation of a single small-scale wind turbine.

Houghton's Goldenrod: Houghton's Goldenrod grows primarily along the northern shores of Lake Michigan and Lake Huron. Western Mackinac County is one of the counties in which the most growth is found. However, it is also listed in Schoolcraft county. Its typical habitat is moist, sandy beaches and shallow depressions between low sand ridges. Given the distance from the shoreline of the two proposed sites, impact to this plant is unlikely.

Pitcher's Thistle: This plant is found on the shorelines or sand dunes of the Great Lakes. Since both projects are set away from the shoreline, in developed areas, impact to the Pitcher's Thistle should be minimal.

Michigan Monkey Flower: This flower grows exclusively in Michigan near the Traverse area and the Straits of Mackinac. The plant may occur in localized pockets or be widely dispersed. It prefers wetter alkaline environments such as marly springs, seepages, mouths of small drainages, and northern white cedar swamp drainages. A white cedar swamp starts the 1-mile hiking trail at Horseshoe Bay, which is near the St. Ignace casino. This flower also flourishes along forest edges and streams near meadow-like areas. Most populations are found near present and past

shorelines of the Great Lakes. Disturbing water drainage may affect the plant. Given the current heavy construction at St. Ignace, the construction and operation of a single small-scale turbine should not impact this flower.

American Hart's Tongue: Four known populations of this fern occur in Mackinac County. Two are owned by the Michigan Natural Association. The U.S. Forest Service manages a population in the Hiawatha National Forest. The other population is located on privately owned land. Northern populations are typically found near limestone and prefer deep shade, high humidity, and moist soil. Although an abandoned quarry exists near the proposed turbine location at St. Ignace, it is unlikely that this site is suitable for growth of the American Hart's Tongue fern due to other nearby development.

Lakeside Daisy: The Lakeside Daisy's presence in Michigan is limited to one known colony on private land near a road in Mackinac County. This location mimics its natural habitat, alvar communities. Given the current casino construction at St. Ignace, it is unlikely that this daisy inhabits the proposed site.

5.2 Other Potential Areas of Concern

The St. Ignace site in Mackinac County is located near the eastern section of the Hiawatha National Forest, near the Horseshoe Bay wildlife viewing area. The site is also located in close proximity to several historic areas and high tourism areas including Mackinaw Island, Marquette Park/St. Ignace Mission, and the Old Mackinac Point Lighthouse. Understanding and mitigating the impact to these view sheds will be important. The County also has three historic bridges.

The Manistique site in Schoolcraft County is located near a state forest and a lake, along U.S. Hwy 2. Portions of the U.S. Highway 2 corridor have received visual enhancement plan grants. The project is approximately 7 miles from the Rainey Wildlife Area, which is known for bald eagle viewing. The county has two historic bridges.

5.3 Recommendations

The St. Ignace and Manistique areas have some areas of concern that would normally warrant an EA. However, construction of the health center at Manistique was completed in 2003 and construction of a new casino at St. Ignace started in 2004. Any EAs conducted for these projects may be sufficient for use as the EA for installation of a small-scale wind turbine. The area disturbed by the tower construction is minimal compared to the buildings.

Though avian studies probably were not conducted for the construction of the health center or new casino, they are often required for large-scale wind turbines. Small-scale turbines, located closer to the ground, often do not interfere with migratory paths. However, if a lattice tower is used, examination of its potential use by Bald Eagles as a perch may be warranted.

GEC recommends that these initial conclusions be verified by the Tribe's environmental specialist, and that the specialist work with the local USF&WS office to obtain a "finding of no significant impact" for any area of potential concern.

Section 6 - Economic Analysis

6.1 Capital Cost Estimate

Conversations with Bergey staff, Entegrity staff, installers, and GEC industry knowledge provide the basis for the capital cost estimates shown in Table 6-1. Although the EW15 is 2.5 times more expensive than the Bergey, it provides 6.6 times more capacity (66 kW maximum output) as reflected in the $/kW cost.

Table 6-1.
Estimated Capital Costs, 120 ft Self-Supporting Lattice Tower

	Bergey	EW15
Turbine	$24,750	$77,000
Tower	15,100	33,000
Shipping	2,500	4,000
Electrical Wiring	2,820	3,000
Foundation	9,000	12,000
Assembly & Erection	2,100	3,000
Interconnection	500	24,000
Commissioning		4,000
Tax, Permits, Fees	6,300	6,300
Total ($)	63,070	169,300
Total ($/kW)	6,307	2,565

6.1.1 Turbine, Tower, and Shipping

6.1.1.1 Bergey

This is a 60 Hz, 10 kW machine that weighs approximately 1,050 lbs. The rotor has a diameter of 23 ft (7 m). The inverter has fully automated operation and converts the wind power to utility power at 240 Vac. The turbine price covers the equipment cost for both the wind turbine and the GridTek 10 inverter.

The tower price covers the cost of a 120-ft (36.6-m) self-supporting lattice tower. The price includes the tower sections and associated hardware, anchors, furling cable and furling winch mounting hardware, special tower grounding hardware, and ground rods.

Bergey provided cost estimates for shipping the turbine, inverter, and tower to St. Ignace and Manistique. It costs a little more to ship to St. Ignace than to Manistique, $2,400 and $2,300, respectively. For the cost estimate, GEC conservatively assumed $2,500.

6.1.1.2 EW15

The EW15 is a 60 Hz, three-phase machine. The weight on the foundation is approximately 12,500 lbs. This turbine produces utility power at 480 Vac.

Entegrity provided an all-inclusive cost for the turbine, tower, blades, controller, and anchor bolts of $110,000. In Table 6-1, GEC assumed a breakdown of 70/30 between turbine and tower. Entegrity also provided an estimate of shipping costs for shipping to California. Since the components would only be going as far as the UP, GEC assumed $4,000.

6.1.2 Electrical Wiring

A wiring kit must be purchased for the Bergey. It includes a fused disconnect switch, lightning surge arrestor, armored tower cable, and connectors. This provides wiring from the turbine to the base of the tower. The cost of $2,820 also includes 250 ft of cable for connecting the turbine to the inverter, a trencher, and labor. The wiring cost for the EW15 assumes 200 ft of cable, and labor and equipment for an underground interconnection to the existing building's distribution panel.

6.1.3 Foundation, Assembly, and Erection

Foundation costs include equipment, material, and labor costs. The cost also depends on the rotor size. Larger rotors require deeper and larger foundations to counteract stresses. Therefore, the foundation for the EW15 costs more than for the Bergey. Assembly and erection includes erecting the towers and assembling and attaching the turbine components to the top of the tower.

6.1.4 Interconnection

The utility interconnection requirements vary based on the turbine size and existing hardware (e.g., metering, panel box) at the prospective site. The utility, Edison Sault, does not expect to require any changes for the 10 kW Bergey. GEC included $500 for any fees or utility review required for installing the Bergey.

However, when asked how increasing the turbine size to 66 kW might impact the connection, using the same configuration as with the Bergey, the utility requirements became much more stringent. Edison Sault will require submission of fees and interconnection plans following the *Michigan Utility Interconnection Procedures for Projects with Aggregate Generator Output of 30 kW or More, but Less than 150 kW*. Costs associated with meeting these requirements could include a disconnect switch, metering, and relay, which could range between $8,000 and $15,000. Additional costs would be incurred for a breaker, transformer, interconnection study, communication circuit, and other utility agreements. GEC estimated $24,000 for all these costs.

6.1.5 Other

Other cost components may include commissioning, sales taxes, permits, and fees. GEC assumed similar costs for taxes, permits, and fees. The quote for the Bergey did not include commissioning while the EW15 did. The 10 kW system is small enough that formal commissioning charges are not necessary. The electrical contractor and utility acceptance should cover this.

6.2 Funding Opportunities

GEC reviewed federal, state, and organization-sponsored funding opportunities for the purchase and/or installation of wind turbine equipment. Most incentives supported industry initiatives, facilitating the development and production of renewable energy equipment. However, the DOE offers a funding opportunity that should allow for the purchase of a renewable energy system.

The DOE's funding opportunity, titled "Renewable Energy Development on Tribal Lands," can be used for feasibility studies or sustainable renewable energy development projects. Development projects must be the result of a previously conducted feasibility study, such as this study. The project must be located on tribal land. Applications may include generation for local consumption. The funding description does not specify if the funds may be used only for equipment purchase or towards the total capital cost of a project. Awards are subject to the amount of funding, if any, appropriated by Congress. Since the funding level is uncertain, GEC ran a sensitivity scenario.

6.3 O&M Cost Estimate

Conversations with Bergey staff, Entegrity staff, small wind turbine operators, and GEC industry knowledge provide the basis for the operations and maintenance (O&M) costs. O&M costs encompass annual inspections, oil changes, bearing replacement, etc. The Bergey and the EW15 have different maintenance requirements.

The Bergey has a direct-drive system with few parts. An annual inspection should be sufficient to ensure proper operation of the turbine. Given the winters in the UP, this inspection should be conducted regularly. The bearings will need to be replaced approximately every 10 years. Annualized, the estimated O&M cost for the Bergey is $600/yr. The Bergey also comes with a five-year warranty.

The EW15 is a much larger and more sophisticated machine, and therefore, requires more maintenance. The machine should be inspected every six months with oil changed as needed during these inspections. Component replacements may occur more frequently and will cost more than the Bergey. The estimated annualized O&M cost for the EW15 turbine is $2,000/yr. The EW15 comes with a one-year warranty.

GEC assumed the escalation rate on the O&M costs to be 5% per year.

6.4 Avoided Energy Cost

Edison Sault serves the Tribe under the Large General Service rate schedule. This schedule has a customer charge, distribution demand charge, energy charge, and a power supply charge with demand and energy components. A wind turbine at either site would help reduce the kWh of energy consumed. The average energy charge under this rate schedule is 4.2 ¢/kWh. Therefore, the Tribe would avoid paying 4.2 ¢/kWh for every kWh produced by the wind turbine.

The wind turbine's operation would most likely not reduce billing demand, however. To reduce the billing demand, the wind turbine would need to generate electricity during the peak demand time(s) during the billing period. Furthermore, if the turbine is operating during this time, it could be operating at a range of capacities up to the maximum capacity (i.e., 10 kW for the Bergey or 66 kW for the EW15). To be conservative, GEC assumed no reduction in the demand charges in the analysis. To the extent that peak demand is lowered by the wind turbine's operation, the economics will improve accordingly. GEC assumed the escalation rate on the avoided cost of electricity to be 2.5% per year.

6.5 Discount Rate

The discount rate represents the minimum attractive rate of return on invested money. GEC assumed a low discount rate of 8%. Investors would typically want a higher rate of return. By using a discount rate, the time value of money is included in determining the economic viability of installing a small wind turbine on the Tribe's land.

6.6 Results

In the base case, GEC assumed that the Tribe would pay cash for the turbine equipment and installation. GEC evaluated the net present value (NPV) over the expected life of 20 years. Table 6-2 presents the results. Negative values (indicated by numbers in parentheses) indicate that the capital cost has not been recuperated.

Table 6-2.
Results, NPV ($)

	St. Ignace		Manistique	
	Bergey	**EW15**	**Bergey**	**EW15**
Total Capital Cost ($)	63,100	169,300	63,100	169,300
Net Annual Energy (kWh)	8,500	50,800	8,000	47,400
Base Case, NPV ($)	(57,300)	(158,100)	(57,500)	(159,700)
DOE Grant – 100% Equipment, NPV ($)	(17,800)	(53,500)	(18,000)	(55,000)

At the time of this study, none of the projects is viable, even with a grant towards the total equipment cost. The projects remain uneconomical with a discount rate of 0%. The two greatest factors contributing to these results are 1) the low wind speeds and 2) the low energy component that the Tribe pays for electricity from Edison Sault. These two factors combined show that it is more expensive to operate and maintain the wind turbines each year than the Tribe would realize in savings from reduced electricity purchases. The base-case models are included in Appendix C. The sensitivity models are included in Appendix D.

Since low winds and hence low energy hinder the project's performance, GEC conducted another sensitivity analysis at St. Ignace. Holding all else constant (including capital costs), GEC estimated the annual energy at St. Ignace if the turbine were placed at 50 m. The increased hub height would increase the estimated net annual energy production of the Bergey to 11,300 kWh and of the EW15 to 71,700 kWh. Even with this increased energy and no corresponding increase in capital cost, the projects are not economical at this time.

Section 7 - Conclusions

The Sault Ste. Marie Tribe of Chippewa Indians has shown enthusiasm for supporting wind energy and its incorporation into the Tribe's energy supply. Unfortunately, the wind resource at the five monitored areas was lower than hoped. Only two sites, St. Ignace and Manistique, had average wind speeds of 5 m/s at heights of 40 to 50 m. This wind resource is insufficient for current large-scale technology; therefore, GEC evaluated the feasibility of installing a small-scale wind turbine.

GEC evaluated two turbines, the 10 kW BWC Excel-S manufactured by Bergey Windpower Company and the 50 kW (maximum 66 kW) EW15 manufactured by Entegrity Wind Systems. Both of these turbines would help offset energy purchased from the utility grid. However, the current cost of this technology paired with the low wind speeds and moderate price of utility-supplied energy, makes the installation and operation of these turbines unfeasible at this time.

GEC recommends that all five met towers be decommissioned. The Tribe has several options for decommissioning the met towers, as follows:

- Offer the equipment in exchange for decommissioning services,
- Approach the DOE about using some of the budgeted money for decommissioning the towers,
- Relocate the towers to other tribal land (Tribe will incur some costs), or
- Sell the towers (Tribe may incur some costs).

Appendix A – Robert Owen's Site Assessment Trip Report

Report to Global Energy Concepts on Wind Energy Siting Trip to Identify Potential Wind Energy Production and Meteorological Tower Sites for Sault Ste. Marie Tribe of Lake Superior Chippewa Indians

Introduction

I examined tribal properties and potential wind sites to serve tribal properties owned by the Sault Tribe in the Central and Eastern Upper Peninsula of Michigan ("U.P.") between April 14 and April 17, 2003. The sites I viewed represented a wide range of topographic and surface roughness conditions and a wide range of exposures to three of the Great Lakes. They varied significantly in mean wind speeds and prevailing wind directions. Most were either not close to or not well characterized by nearby wind data sites. Sparse wind data and very complex lake and land breeze interactions involving all three of the Northern Great Lakes combine to provide some serious challenges in estimating wind resources in the broad area of the U.P. served by Sault Tribe facilities. This area would benefit greatly from additional wind resource measurements.

My effort was focused on identifying sites at which wind could be used as a resource to support Sault Tribe facilities and possible measurement sites to evaluate the wind potential at such sites. Prior to visiting site areas of interest, I examined topographic maps of the areas.

I focused on wind resource, electrical load, and grid facilities at sites visited. In the cases of relatively large tribal electric loads, I would look more extensively and farther from the sites currently owned by the tribe to other sites in the area which could be utilized to support the tribal loads with wind generation. In the cases of smaller loads, I would focus primarily at on-site wind generation opportunities. Depending on the size of the potential wind turbines considered for a site, the height of the potential wind monitoring tower could be adjusted to more closely correspond with the generator scale considered for the site. In some cases, monitoring tower height would also be constrained by other practical space constraints.

Where I identified sites of potential interest, I generally videotaped them, both to show the sites and surroundings, including surface roughness characteristics, and to dictate other relevant observations onto the videotape. My videotape for this trip is just under 120 minutes.

Sarah Meyer of Global Energy Concepts assisted the effort to efficiently cover a large geographic area, to document the information obtained on site, and to gather such wind data as could be obtained for the U.P. Sarah's assistance was highly valuable.

The ten areas visited and included in this report[8] were:

(1) Marquette Area;
(2) Christmas Area;
(3) Munising (Wetmore) Area;
(4) Newberry Area;
(5) Sault Ste. Marie Area;
(6) Kinross Area;

[8] After a meeting with Sault Tribe representatives on April 16 advising that the Hessel Casino was in a heavily wooded location, I decided not to visit that location. I was unable to get clear directions to or locate the Escanaba tribal housing in a brief search of the west side north of the Delta County Airport on April 17. This general area lacks relief or other favorable wind-enhancing characteristics away from Green Bay anyway. So this report does not include information about Hessel or Escanaba.

(7) St. Martin Bay Area;
(8) St. Ignace Area;
(9) Naubinway Area; and
(10) Manistique Area.

The area-specific reports follow.

1. Marquette Area

The Marquette Area is in a bowl, topographically speaking, with higher elevations within a few miles to the northwest-west-southwest-south. Although elevations in the city range from about 600 ft upward to around 900 ft, elevations within about 10 miles range upward to about 1300 ft to the northwest, 1700 ft to the west, 1873 ft to the west-southwest, 1640 ft to the southwest, and 1300 ft to the south. The only favorable exposure in the city is to winds from Lake Superior to the north-northeast-east. These do not occur frequently enough on an annual basis to overcome the drawbacks of low relative elevation. Thus, in general, Marquette is not a very windy place. Most locations will not be suited for wind development.

I identified one exception to this general rule, the summit of Marquette Mountain a short distance south of the city of Marquette, which I visited on the evening of April 14. This 1300 ft summit overlooks the city and Lake Superior 700 ft below and is reasonably well exposed to the winds from all directions. This summit is within a few feet of the upper end of a chairlift at the Marquette Mountain Ski Area. It could perhaps accommodate a wind turbine of commercial scale within about 150 ft southwest of the summit. This site has several advantages. It has a well developed grid connection to the Marquette Board of Water & Power municipal electric system already sized to accommodate large chairlift electric loads at the top of the mountain. This grid connection extends, via Highways 553 and 554, all the way to Marquette's power plant and substation on the south side of the city, a distance of 3.5 miles from the top of the ski area. The summit is fairly isolated from nearby homes, but there are some homes to the south-southwest, and I was unable to determine their exact distance from the potential turbine site. Wind turbine noise would not be an issue for the ski area because the chairlifts are already fairly noisy. There is a tall communication tower about 40 ft below and 500 ft west of the summit which could perhaps be used as a wind measurement platform.

The Sault Tribe owns the Eagle Ridge Apartments along Highway 554 north of Marquette Mountain and Mount Mesnard, the next rise north of Marquette Mountain. I looked at this site on April 15 and rejected it due to its tall trees and position in the wind shadow of Mount Mesnard and other topographic features to the southeast-south-southwest-west. It would not have adequate winds for wind development.

I was unable to precisely locate three other tribal residential properties near Lake Superior and the municipal power plant on the south side of town. This area, however, has limited potential for wind development anyway due to a lack of lot space, small electric loads, close neighbors, trees, and a modest wind resource.

The one option which I did note was Marquette Mountain. If the tribe could purchase a small site on this peak and either sell the output to the Marquette Board of Water and Power or wheel it at

low cost through the city electric system to tribal properties connected to that system (such wheeling would actually benefit the city electric grid in this case and thus might be permitted by the utility, as Alliant Energy/IES Utilities does for a wind-turbine-owning school district in Eldora, Iowa), this site could give the tribe a more economic wind option than would be possible at current tribal properties in the Marquette Area because of its much better wind resource and existing grid infrastructure which might require very little improvement to connect a smaller commercial-scale wind turbine (250 kW or smaller). This option would require the active cooperation of the Marquette Board of Water and Power and the ski resort owner, of course. From past contact with the municipal utility on an unrelated matter, I believe that it might consider working with the tribe on a wind project. I do not know about the ski resort owner.
If the Marquette Mountain option is of potential interest to the Sault Tribe, I would recommend meteorological measurements on one of two communication towers nearby. This site would not permit use of a guyed tilt-up tower due to closeness to ski runs. My first measurement choice would be the tower about 500 ft west and 40 ft down the hill from the summit. My second would be a taller communications tower about 1000 ft south of the summit to the east of Highway 553. In either case, I would use two anemometers at each level measured.

2. Christmas Area

The Sault Tribe's Christmas Casino is a comparatively large power consumer, with 575 kVA of total transformer capacity at the casino and parking lot/casino sign locations on the south side of M-28 in Christmas. It appears that the tribe also has a diesel generator of several hundred kW capacity at this location. The utility at this location is Upper Peninsula Power Company. It serves the site with a three-phase distribution line down Highway M-28. The Christmas tribal load could conceivably support a commercial-scale wind turbine in the 750 kW or larger size range.

Unfortunately, the Christmas Casino site is not large enough nor far away enough from nearby residences on either side of M-28 to provide nearly the normally required 1000 ft spacing from residences for a commercial-scale wind turbine.

However, the Christmas Area may have at least some modest wind potential. On the occasion of my visit on April 15, a strong north wind was blowing off of Lake Superior into Christmas. I believe that this area sees a high frequency of northwest-north winds in winter and thermally driven north lake breezes off of Lake Superior, possibly with some local funneling between Fivemile Point and Grand Island enhancing the wind resource in the spring and summer.

Accordingly, I sought to identify nearby sites which might be developed with a commercial-scale wind turbine. A nearby property for sale near the shoreline north-northeast of the casino did not appear to provide adequate clearance from nearby residences and a state park farther northwest along the lakeshore. I rejected it for that reason.

I did locate a sand/gravel quarry property reasonably nearby which appeared to have the potential to accommodate both a commercial-scale wind turbine and a guyed 50-meter meteorological tower with 1000 ft or greater clearances from nearby residences.
This site appeared to have been quarried years ago and was reasonably level, west of the road proceeding north from M-28 along the west side of the bay toward Fivemile Point, Fivemile Point Road. It provided a comparatively large clearing in an otherwise generally forested area. It

appears that more northerly reaches of the quarry north of the identified site, may still be actively being mined for sand/gravel, although I observed no quarrying on April 15. From a wind resource standpoint, proximity to the quarry operation is actually an advantage, particularly if the quarry is growing in a northward and northwestward direction. The bigger the open area in these directions, the better the wind resource becomes. This site appeared to have at least 1000 ft clearance from homes across Fivemile Point Road near the shoreline (and good vegetative screening from most such homes) and 800 ft-1000 ft clearance from the closest home to the south on the west side of Fivemile Point Road. If more clearance would be required in that case, the site could be moved northwest within the quarry.

This site would require a three-phase power line of about 1.1 miles to connect to the Christmas Casino. Such a line could be constructed for perhaps $60,000, including burying the portion from the lighted sign to the transformer pad east of the casino and installing a pad transformer on the new underground line to serve the sign/parking lot. The wind turbine could be operated "within the fence" of the casino's electric grid such that the turbine output would reduce the energy bill for the casino, primarily, and secondarily sell any small excess back to the utility on the occasional very windy day (depending on the buyback rate offered by the utility, it might be better to store the energy in the form of, for instance, hot water, or ice and use it later in the casino). Its major effect would be to reduce the kWh portion of the casino's UPPCo electric bill. It would likely slightly increase the kW portion of the bill.

Development of this site as a wind turbine or wind measurement site would appear to be possible without disturbing the quarry operation. This portion of the former quarry appears to be completely unused. It might be possible to acquire a small piece of land for wind testing/development here at a reasonable cost. I was unable to determine the owner of the property on April 15.

Wind measurements at this site would be helpful in characterizing the wind resource in both the Christmas and Munising Areas. My observations on April 15 lent some credence to the hypothesis that there is some acceleration of northerly winds between Grand Island and Fivemile Point. It is possible that the quarry area could benefit from this acceleration, but measurements would be needed there to be sure.

I recommend the quarry site as a site for a 50-meter measurement tower.[9]

3. Munising (Wetmore) Area

I visited a small enclave of tribally owned homes in an elevated area southeast of Munising and north of M-28 on April 15. These homes appeared to be individually metered, with the tenants paying their own electric bills at present, and with a tribally owned maintenance building on the north edge of the enclave for which the tribe presumably pays the electric bill. From all appearances, this is a pretty modest electric bill for the tribe. This development did appear to include a significant amount of undeveloped land owned by the Sault Tribe to the west of the northernmost building and to the north or northwest of most of the homes in this development. This enclave is currently served by single-phase electric service from UPPCo, but three-phase

[9] Screw-in anchors might not be adequate by themselves for a 50-meter tower at the quarry site as the soil probably consists mainly of sand and gravel of limited holding power.

service is available within .5 mile to the west along M-28. Three-phase service could be extended to the enclave at a cost of about $25,000. This would be necessary to consider a 50-kW wind turbine option.

This enclave would present several wind development options. One would be to install a small grid-connected wind turbine to just offset all or a portion of the kWh usage of the tribal building at the north end. A more ambitious option would be to install a turbine in the 50-kW range or 2 or 3 20-kW turbines to attempt to offset a significant portion of the total electric use of the entire neighborhood. A way to do this without turning the Sault Tribe into a regulated utility service provider would be to buy the local grid, remove the electric meters, and include electric service in increased rent charged to tenants. A third option would be to have the Sault Tribe buy the electric infrastructure and the meters on site and become the distribution utility or cooperative for the entire site, but still buy whatever power the site requires above and beyond the wind generation from the existing supplier. A fourth option would be for the Sault Tribe to install wind and backup generation and supply all power required at the site from Sault Tribe resources. By using a combination of wind and, for example, several propane-fueled generators with waste heat recovery to heat water and provide DHW and space heat to nearby homes, the Sault Tribe could perhaps develop a fairly efficient, self-contained, mini-grid local energy system similar to a small wind-diesel system based on local wind and efficient dual power/heat use of propane. It is unlikely that any of these options would actually save money compared to present energy service arrangements, but they could produce environmental benefits as compared to the largely coal-based generation now presumably serving the Munising Area.

A further option to enhance the wind potential of this community would be to buy open land just north of the existing Sault Tribe holdings to include a potentially windier site than those now owned by the tribe about 500 ft north-northwest of the tribal maintenance building. If available, this land would be windier.

Whether wind development here would be limited to existing tribal land or a parcel to the north would be included (Appendix A includes the lat/long for the latter), it would be desirable to remove some trees to enhance and protect the existing wind resource.

If any of the wind development options are of interest to the tribe, it would be desirable to measure on-site winds. There are no existing measurements providing much insight into the wind resource of this area. The soil in this area is sandy, perhaps requiring additional or dead man anchors for a met tower.

The existing site would require some cutting of small trees to accommodate even a 40-meter wind measurement tower. If the tribe would prefer a small wind option to just offset electric needs of the maintenance building, I would recommend a 40-meter met tower at this site.

If the tribe would prefer a more ambitious wind development at the site up to a 50-kW turbine, I would recommend a 50-meter met tower at this site. This would require more cutting of trees on the existing tribal property or purchase of more open acreage from the neighbor to the north. The property just to the north appears a little windier.

4. Newberry Area

This area is situated on a reasonably large plateau surrounded by lower terrain at a distance of a few miles. It is possible that more open portions of the plateau near Newberry and hills to the west have a somewhat enhanced wind resource. The wind resource of the area is somewhat understated by the 10-meter anemometer at the nearby Luce County Airport to the northeast. This anemometer is shadowed substantially by deciduous forest to the northwest-north-northeast and to some degree by coniferous trees to the west-southwest. I had an opportunity to videotape the wind sensors there.

The tribally owned property at Newberry is just south of Highway M-28. This residential enclave is somewhat larger than its counterpart near Munising. It is in some ways similar. Residences are currently individually metered for electricity. Thus, the wind options are similar to those at Munising.

In the case of Newberry, though, it appears that there may be a larger electric load at the tribal health center near the north end of the property. Thus, if the Sault Tribe wished to offset part of the electric bill of this facility for which it pays, it might wish to consider a larger wind generator to do so.

Also, in the case of Newberry, the current power supplier is Cloverland Electric Cooperative, which may have a higher cost per kWh of electricity than UPPCo.

An important difference from Munising is that this tribal property appears to have room for only one wind turbine. The only substantial open area is between the health facility and Highway M-28. This area could accommodate a Jacobs 20-kW wind turbine or, conceivably, a turbine up to 50 kW in capacity. Depending on tower height, such a turbine might require the placement underground of the Cloverland power line crossing the north portion of the property south of Highway M-28.

Also, it is important to recognize that the proximity of the Luce County Airport could constrain tower height at this site. For instance, it might preclude installation of a tower of greater than 100 ft height or preclude an installation altogether. This will need to be checked with aviation authorities.

This same concern and a need to keep any met tower out of fall distance from the Cloverland power line could limit the met tower height at this site as well. If the Sault Tribe is interested in developing wind at this site and the FAA/state aviation authorities do not discourage such an installation, I would like to see a met tower of 30 or 40 meters at this site approximately centered in the open area north of the health facility and outside of fall distance from the power line along M-28. I do not believe this site can safely accommodate a 50-meter guyed met tower.

5. Sault Ste. Marie Area

I examined a number of tribal and other properties in the Sault Ste. Marie Area on April 15 and 16. The Sault Tribe appears to have its greatest concentration of members and tribal electric load in the Sault Area.

Tribal load is particularly concentrated at the Kewadin Casino and Hotel and nearby facilities, notably including the Big Bear Center. I noted transformer ratings at these two facilities alone totaling at least 3750 kVA. In addition, there are other smaller tribal facilities and many tribally owned housing units in the same general area.

In the immediate Sault Area, the wind resource tends to peak in open terrain high on a north-northeast-south-southwest-oriented ridge which extends from Sault Ste. Marie south-southwest in the vicinity of I-75. This ridge appears to contribute to a prevailing northwest wind direction at Sault Ste. Marie Sanderson Airport even in summer. A lake breeze off of Whitefish Bay is probably also a factor.

Unfortunately, the wind resource does not appear to be nearly as high in the immediate vicinity of the tribal casino and recreational center. These are located well down the east side of the ridge fairly close to the elevation of the St. Mary's River. These areas are also wooded where not yet developed or subject to wind shadowing associated with large buildings. After a careful look, I did not identify any tribal sites near the casino or recreation center which appeared to have a reasonable wind potential.

The Sault Tribe also has a significant concentration of property with significant electric loads farther southwest. The tribal health facility and several motel properties on the south end of town near Business 75 are higher in elevation and thus would have greater potential than the casino-recreational center area. However, undeveloped portions of these properties are wooded too, limiting their wind potential. In addition, these properties would be constrained by proximity to other, predominantly commercial, properties nearby. They could also be constrained for commercial-scale wind development by proximity to Sault Ste. Marie Sanderson Airport and related tower-height restrictions. I did not identify any sites in this area that I could recommend for wind development.

I did find one tribally owned site, however, which I think warrants a hard look and wind monitoring. The Odenaang site, which I visited on April 16, was more promising than other tribally owned sites I viewed in the Sault Area.

This nearly 300-acre site would appear to have the potential to accommodate a commercial-scale wind turbine without violating a 1000 ft setback from nearby residences. It also appears to have a considerably better wind resource than any of the other tribal sites I viewed in the Sault Area.

Based on current home installations, this site might conceivably accommodate two commercial-scale wind turbines, but this might constrain future development of northeast portions of the site for residential purposes. Even a single commercial-scale wind turbine would constrain the residential development of the northwest part of the property.

The Sault Tribe electric load in the Sault Area could perhaps support as many as six 1.5-MW wind turbines. The Odenaang site does not have the potential to support that much wind development.

However, in addition to being tribal property, the Odenaang site has a very strong location advantage. It is within reasonable power-line distance of the tribe's load centers near the health center and the casino-recreational complex. Thus, the Odenaang site could provide a good site for an initial commercial-scale turbine if the tribe decided to get its feet wet in wind in a gradual or staged manner.

Initially, the tribe could install a single turbine at Odenaang and build a power line north from this turbine along Seymour, 3 Mile and Shunk Roads about 2.7 miles to its casino, connecting any intervening tribal facilities to the line (and disconnecting them from Edison Sault) in the process. Electrically, this would have the effect of lumping these smaller tribal facilities on Shunk into the same Edison electric bill with the casino. The overall effect of the wind generation would be to reduce the tribe's kWh bill from Edison Sault. The tribe would still be connected to and still pay Edison Sault for power (but pay less).

Constructing this line, however, would help create a future option to sever or reduce ties to Edison Sault.

The tribe could also later build a line from the intersection of Seymour and 3-Mile Road west to the tribal health center and nearby motels farther north and west. It could later build a line east from the casino to the Big Bear Center. It could later build a line north from the casino to the Bahwetting School. In this gradual or phased manner, the tribe could create its own distribution grid to serve tribal facilities in the south-central and southeast portions of the Sault Area.

Once the great majority of tribal load was served from tribal-owned distribution lines, the tribe could connect to a 69-kV line (e.g., near the school) when it was financially advantageous to do so and declare its independence from Edison Sault in those portions of the Sault Area. It could buy power from any regional utility over the 69-kV line. It could also bring in power from a tribally owned wind farm south of town or buy backup or sell excess power over the same 69-kV line, just as Edison Sault could.

At any point that the economics seemed promising, the tribe could install an efficient gas-fired co-generation plant at the casino and use it to provide heat/cooling/electricity whenever the tribal wind generation did not meet the current requirements.

With access to the 69-kV transmission grid, the tribe would not be constrained as to where wind energy was produced. It could buy hundreds of acres south of the Sault and raise bison or graze other livestock and produce wind energy on windy open range land close to a 69-kV line.

The tribe would have to pay for wheeling the power on the transmission line, but these payments are normally fairly reasonable, potentially less than the cost of, for example, building a distribution line southwest of the Sault to connect the wind farm farther southwest directly to Odenaang. Moreover, owning a line from Odenaang to the casino would create an option to build a cheaper line to a bigger wind farm to the southwest, if necessary, to avoid excess transmission costs.

I did investigate some areas near the intersection of I-75 and M-28 as potential future wind development sites for the tribe. One area of particular note that I found was the quarter section northeast of the intersection of M-28 with Maple N Road. This area is almost devoid of trees and quite open to the northwest. This area shows some evidence of flagging of the few trees there, indicating an above-average wind resource with a prevailing northwest wind direction during the growing season (similar to Sanderson Airport).

A 69-kV line crosses this property north of M-28, proceeding east to the Nine Mile 69-kV Switching Station on the east side of I-75. This locale is connected by multiple 69-kV lines to Sault Ste. Marie.

A line from this area to Odenaang at distribution voltage would stretch for about nine miles to the southwest, but could probably be built for $450,000 or less. This kind of investment is thinkable if the tribe would contemplate a 6-MW or larger wind farm just north of M-28. It is also possible that there could be a few single-turbine sites in open areas between Odenaang and M-28, permitting the line to be built in stages.
I would recommend that the tribe consider relatively windy sites well southwest of the Sault Area not currently owned by the tribe if it contemplates more than one commercial-scale wind turbine. If it just contemplates one such turbine, I recommend that the tribe consider the Odenaang site first.

As to wind data in the Sault Area, the existing data from the Sanderson Airport clearly understates the wind potential of the ridge paralleling I-75. The anemometer at Sanderson is poorly placed in a location near the northeast corner of the airfield highly sheltered by nearby buildings and trees.

I would recommend that the Sault tribe seek to site a 50-meter met tower at the Odenaang site if aviation authorities confirm that it could be developed.

In addition, if the tribe is seriously considering more than a single commercial-scale wind turbine at Odenaang to serve its Sault electric load and needs to consider using another site in addition to Odenaang, I recommend that the tribe also instrument a 50-meter met tower or taller communications tower in the vicinity of I-75 and M-28 or between Odenaang and that area. There are three such communication towers in that area, not counting the somewhat shorter one behind the Cloverland Office on M-28 just west of I-75. I would be interested in measurements to 60 meters or higher (80 meters would be desirable) at these towers.

I would also be interested in siting a 50-meter met tower directly on a potential wind farm site such as the quarter section just northeast of the intersection of M-28 and Maple Road north or a comparable site near I-75 farther northeast.

The idea of the second and third Sault Area towers would be to get wind measurements representative of windy ridge locations in the area described above.

6. Kinross Area

I visited the Kinross Area on April 16. I was disappointed to learn that the tribal residential properties at this locale were not particularly open nor windy and were, unfortunately, quite close to Chippewa County International Airport, precluding installation of a tall tower. They also lacked significant room to install a wind turbine in what was essentially a suburban community. I rejected the residential site as a potential wind measurement site.

I also viewed the tribal health center. It lacked any room to install a wind turbine or met tower and was even closer to the airport. I rejected this site too.

7. St. Martin Bay Area

I visited an area north of St. Martin Bay at the outlet of Nunns Creek on April 16. This is a tribally owned property formerly used as a fish hatchery just north of Highway 134.

This site may have some potential for a small wind turbine installation. It may also have micro-hydro potential and the potential to go off grid entirely.

This site has several practical constraints affecting the raising of a guyed met tower, limiting the potential height of such a tower to about 20 meters. These constraints would not preclude installing a small wind turbine on a 120 ft lattice tower, however.

If the tribe is interested in considering wind at this site, I recommend installation of a 20-meter met tower there. Even a 20-meter met tower might require under grounding of a power line connecting two outbuildings on the site.

8. St. Ignace Area

I visited the St. Ignace Area on April 16 and 17 and identified two sites potentially warranting wind monitoring.

I first visited the St. Ignace Casino and its environs. This casino appears to also have a reasonably large electric load. Its transformer capacity is 750 kVA. Just north of the casino is a tribal filling station with a 37.5-kVA transformer. About 1000 ft east is a tribal clinic with a 225-kVA transformer. Even closer than the health clinic are a number of tribal-owned homes, but these are individually metered, with electric bills presumably paid by the tenants.

It appears that the tribe could consider a MW-scale turbine to lower tribal electric kWh bills at this locale—if such a turbine would not interfere with expansion plans.

The tribe also has some motel loads several miles south in St. Ignace on the Lake Huron side. It could be more problematic to connect these loads to the St. Ignace Casino since they are smaller, more seasonal in character, and fairly distant. The economics of a line connecting them (about 3 miles) might depend on whether the tribe purchased other properties in the area.

One of the potential commercial-scale wind sites at St. Ignace appears to be on casino property southeast of the parking area. This site is modestly interesting because it is close enough to Lake Huron to benefit from that proximity in terms of increased wind resource.

This site is fairly close to the Mackinac County Airport, about 2.1 miles south at a slightly lower elevation. This could preclude use of the site near the casino. This issue needs to be carefully investigated with aviation authorities in the near term to evaluate the viability of this site if the site appears otherwise viable.

However, since I visited the site, tribal sources have advised that a major casino expansion is in the works at Kewadin Shores Casino, raising the issue of whether there will be enough room to maintain reasonable clearance from parking facilities.
Another issue of potential concern is proximity of the site to residences on Rabbit Back Road southeast of the site. It would probably be possible to position the site on the tribal property to keep nearby residences not owned by the tribe outside of a 1000 ft radius. However, such positions might then be closer to tribal-owned housing to the east of the casino, some of which would likely be within 1000 ft of the turbine, or to an expanded casino.

This site could present some complications in terms of placement of a meteorological tower also. While there is some space southeast of the casino and parking area, it was not clear from my visit how this space is now used. It does appear to have been used in the past for events with substantial numbers of spectators. If it would still be used for such purposes, this might complicate placement of the met tower and any wind turbine.

In addition, anchoring the met tower at this site could present some complications as the site appears to have been used in the past for quarrying sand or gravel. It might have poor soil holding characteristics and require excavation to place dead man or other non-standard anchors.

In addition to other uncertainties about the site near the casino, I am also uncertain about the wind resource there. The airport anemometers a few miles south are non-functional at this time (with only three of the original six cups attached) and are poorly placed in a sheltered location subject to large building and tower wakes. When they did function, they understated the local wind resource by a large margin.

I would be very uncomfortable about recommending a wind installation near this casino without 50-meter wind data from the area confirming an adequate wind resource.

On the other hand, I could imagine that a wind turbine on a tall tower there could have great advertising value for the tribal casino even if the wind resource was modest.

Lake and land breeze phenomena near St. Ignace are complex due to the geometry of the lakeshores of Lakes Huron and Michigan in the vicinity. I would not be surprised if wind resources are better on the Lake Michigan side of the peninsula extending southeast toward the Straits of Mackinac. This, however, is about 5 miles away from the casino, and has some residential and other high-value areas which might make it difficult to find a suitably large, open, parcel outside of the Hiawatha National Forest which could be developed. This side of St. Ignace

also is fairly close to the airport, which is at a lower elevation, and could also raise serious airspace protection concerns if a tall wind turbine were placed there.

With the likely difficulty of siting a turbine on the west side of St. Ignace, I looked for a backup site in a different direction.

The area that I identified is an area well northwest of the Kewadin Shores Casino, near the hamlet of Moran. This area is of moderately high elevation with a large inland lake, Brevoort Lake, to the west and a smaller lake, Round Lake, and a marsh to the southwest. The area was formerly farmed and has a large expanse of open land, although some of this is beginning to revert to woodland.[10]

I visited this area on the morning of April 17 and found the wind chill values encouragingly low. Also, there was some apparent flagging of trees indicating a prevailing southwest wind during the growing season in this area and suggesting an above-average wind resource.

An area I particularly liked for its wind characteristics was an area west of Wartella Road, south of Brevoort Lake Road, and north and east of Highway 123. I did not determine the ownership of this land but did note that it did not seem to be currently in farm use.

There were other potential sites in the same general area. While the potential sites in this area are some 8 miles from the casino, they are also likely considerably windier, quite remote from airports, and likely to be easier to get permission to develop. In addition, much of the potential line route via Highway 123 and Mackinac Trail is occupied by a Cloverland Electric Cooperative three-phase distribution line which might permit pole sharing with a tribal line from the wind farm to the casino. I estimate that the tribe could build its own line from a Moran wind farm to the casino for $400,000 or less. At a cost of about $200,000, the tribe could build a line east to I-75, where a north-south 69-kV line runs parallel to the interstate. There would be an option to develop a wind farm near Moran, build the above line and a 69-kV substation, and send the power both to the Sault Area and St. Ignace by wheeling through the 69-kVgrid that serves Edison Sault. Tribal wind turbines near Moran would be visible from I-75 about 4 miles to the east and accessible to tourists via Highway 123.

If the tribe is interested in exploring the Moran wind farm option, I recommend a 50-meter met tower at any proposed initial turbine location there.

9. Naubinway Area

I visited Naubinway on April 17. The Sault Tribe-owned residential property on the north side of U.S. Highway 2 in this community has an unlighted billboard for the St. Ignace Casino as well as a house on it.

[10] If the tribe were to purchase a large acreage in this area and graze the land with bison or other cattle, the forest progression could be halted with chainsaws and the present reasonable wind resource preserved. Global warming may eventually do likewise if predicted drying materializes in this area, but grazing would be a good insurance policy.

There is a potential small wind turbine site on this property northwest of the billboard. A turbine there could be used to provide electricity for the home or perhaps to light the billboard or both. In the second case, presumably an additional meter would be installed and the Sault Tribe would pay the electric bill. Thus, in this case wind production would reduce the tribe's electric bill.

The same general area would have room for a 30-meter met tower.

However, to safely erect a met tower here would require placing the electrical service lines to the home underground.

In view of the apparent small electric load at this location, I would give this site a somewhat lower priority than most of the other sites. This priority also reflects my lack of certainty that this area has a good wind resource. It is .5 mile inland from the shoreline in a southwest direction. However, buildings in that direction are modest in size, and the trees nearby to the southwest are scattered.

10. Manistique Area

I also visited Manistique on April 17. Manistique has a tribal housing development northwest of the Schoolcraft County Airport east of town. This development has no room for even a small wind turbine. Even a small wind turbine could be a concern from an airspace safety standpoint for aircraft turning left to land in an easterly direction at the airport. Thus, I rejected the housing development as a potential wind turbine or met tower site.

I did likewise with the Manistique Casino on the north side of U.S. 2 just southeast of the airport. This is too close to the airport for a tall met tower or a wind turbine. The airport already has an anemometer west of the north-south runway.

A large transformer capacity of about 500 kVA does suggest, however, that the casino is a relatively large power user, which could normally utilize the output of a commercial-scale wind turbine. Tribal health and motel facilities on the north side of U.S. 2 about 2 miles west of the casino also appear to be significant power consumers.

Accordingly, I looked for a site for a commercial-scale wind turbine near Manistique but at a greater distance from the airport on property not currently owned by the Sault Tribe. I focused on the Manistique Lakefront and on areas east of Manistique near U.S. 2.

On the lakefront, I identified the inside of the breakwater south of the city as a possible offshore site for a commercial-scale wind turbine. While possible and possibly of some enhanced advertising value for the tribal casino, such a site would create substantial additional installation expense as compared to an inland site, could generate significant public opposition due to its visual prominence in the Manistique Harbor, and would also likely require special equipment like an air sled to access the site for maintenance from mid December to mid April. I am not confident that the likely increase in wind resource at this location would outweigh the increase in costs as compared to a nearby inland site. If the tribe would be interested in investigating this option, the existing lighthouse at the south end of the breakwater would be a potential wind measurement platform for a Manistique offshore site. This would require a custom wind sensor

mount design, perhaps similar to that used by the Great Lakes Environmental Research Laboratory for its Great Lakes lighthouse met stations, and probably require U.S. Coast Guard approval. That would likely take months to obtain.

Manistique does actually have a NOAA ASOS station very close to its lakefront on the north side of U.S. 2, and this station produces useful 10-meter wind data for some wind directions. Wind data from about 20 meters atop the lighthouse would be less affected by wakes from trees, buildings, and billboards and would be more useful.

I do believe there is adequate room for a commercial-scale wind turbine on the inside of the breakwater close to its south end. Such a turbine would be more than 1000 ft from any residence or commercial building. Unfortunately, it would also be about 5 miles from the Manistique Casino, about 3 miles from the tribal health and motel facilities. I identified two possible inland sites for a single commercial-scale wind turbine east of Manistique. One was on the west portion of the sole dairy farm I noted in the area, the Pawley Farm, south of U.S. 2 about 3.6 miles east of the casino. A second was east of Kelley Road and .25 mile north of U.S. 2 about 5.4 miles east of the casino. Neither site is particularly high nor well endowed with wind resource. Trees limit the wind resource in both areas. I would expect the commercial-scale sites near M-28 and I-75 and near Moran to be significantly windier.

If either of these inland sites meets with the tribe's favor, I recommend 50-meter met tower measurements at the selected site. Either site could present some anchoring difficulties, with shallow limestone/dolomite possible.

Conclusion

The above summarizes my observations and recommendations concerning possible met tower sites for the Sault Tribe.

Appendix B – Preliminary Environmental Analysis

The five wind monitoring sites each contain some areas of concern that will need further investigation as project development continues. Several of the sites are located near one or more bodies of water and could potentially be located in a sensitive watershed. Some rivers located in the five counties fall under either or both the Michigan Scenic Rivers Act and the Federal Wild and Scenic Rivers Act. These acts define the type of activities allowed along certain stretches of each river. Furthermore, stretches of several U.S. and State highways in Michigan have received visual enhancement grants. Though these projects appear to focus on short-distance view sheds (i.e., buildings located along the road), wind power projects located within the overall visual enhancement viewshed may or may not be more susceptible to local visual impact concerns. Since all five sites are located on tribal land, some local, county, state, or federal environmental restrictions may not apply.

Site 8001, Wetmore, in Alger County is near the Au Train Basin State Wildlife Management Area, the Sand Point March Trail/Pictured Rocks National Lakeshore, and the western portion of the Hiawatha National Forest. The county has four historic bridges. Four threatened species and one endangered species exist in Alger County.

Site 8002, Odenaang, in Chippewa County might be in the viewshed of the Paradise Project visual enhancement plan. The site is also located near several historic sites, and three historic bridges are located in Sault Ste. Marie. Seven threatened species and one endangered species exist within the county.

Site 8003, St. Ignace, in Mackinac County is located in the eastern section of the Hiawatha National Forest, and near the Horseshoe Bay wildlife viewing area. The site location may be impacted by visual enhancement grants along M-134 and U.S. Hwy 2, if it is in either of those two view sheds. The site is also located in close proximity to several historic areas and high tourism areas including Mackinaw Island, Marquette Park/St. Ignace Mission, and the Old Mackinac Point Lighthouse. Understanding and mitigating the impact to these view sheds will be important. The County also has three historic bridges. The project site might also be in the watershed of the Carp River, one of the rivers listed in the Michigan Scenic Rivers Act. Eight threatened species, three endangered species, and one candidate species exist within the county.

Site 8004, Manistique, in Schoolcraft County is located near a state forest and a lake, along U.S. Hwy 2. Portions of the U.S. Hwy 2 corridor have received visual enhancement plan grants. The project is approximately 7 miles from the Rainey Wildlife Area, which is known for bald eagle viewing. The county has two historic bridges. Six threatened species and two endangered species exist within the county.

Site 8005, Newberry, in Luce County is surrounded on three sides by state forest. Three threatened species and one endangered species exist in the county.

Following is a summary of the threatened and endangered species in the five subject counties based on information provided by the U.S. Fish & Wildlife Service.

Project Site	County	Species	Status
Wetmore	Alger	Canada Lynx	Threatened
		Gray Wolf	Threatened
		Bald Eagle	Threatened
		Piping Plover	Endangered/Critical Habitat Designated
		Pitcher's Thistle	Threatened
Odenaang	Chippewa	Canada Lynx	Threatened
		Gray Wolf	Threatened
		Bald Eagle	Threatened
		Piping Plover	Endangered
		American Hart's Tongue Fern	Threatened
		Dwarf Lake Iris	Threatened
		Houghton's Goldenrod	Threatened
		Pitcher's Thistle	Threatened
St. Ignace	Mackinac	Canada Lynx	Threatened
		Gray Wolf	Threatened
		Bald Eagle	Threatened
		Piping Plover	Endangered
		Eastern Massasauga	Candidate
		Hine's Emerald Dragonfly	Endangered
		American Hart's Tongue Fern	Threatened
		Dwarf Lake Iris	Threatened
		Houghton's Goldenrod	Threatened
		Lakeside Daisy	Threatened
		Michigan Monkey-Flower	Endangered
		Pitcher's Thistle	Threatened
Manistique	Schoolcraft	Canada Lynx	Threatened
		Gray Wolf	Threatened
		Bald Eagle	Threatened
		Piping Plover	Endangered/Critical Habitat Designated
		Kirtland's Warbler	Endangered
		Dwarf Lake Iris	Threatened
		Houghton's Goldenrod	Threatened
		Pitcher's Thistle	Threatened
Newberry	Luce	Canada Lynx	Threatened
		Gray Wolf	Threatened
		Bald Eagle	Threatened
		Piping Plover	Endangered/Critical Habitat Designated

Appendix C – Base-Case Models

Table C - 1
St. Ignace: Bergey Base Case

Capital Cost					**Cost**
Equipment Cost ($)					42,670
Installation Cost ($)					13,600
Other Capital Costs ($)					6,800
Total Capital Cost ($)					63,070
Plant Input Data					**Rate**
Total Net Capacity (kW)					10
Gross Annual Energy Production (kWh)					9,290
Losses (%, kWh)				8.3%	771
Net Annual Energy Production (kWh)					8,519
Economic Input Data				**Rate**	**Escalation**
First Year O&M ($/kW)				30	5.0%
Avoided Energy Cost (¢/kWh)				4.20	2.5%
Discount Rate				8.0%	
DOE Funding Percentage				0%	

Year	Capital Cost ($)	O&M ($)	Total Cost ($)	Avoided Energy ($)	Net Cost ($)
0	(63,070)		(63,070)		(63,070)
1		0	0	358	358
2		0	0	367	367
3		0	0	376	376
4		0	0	385	385
5		0	0	395	395
6		(383)	(383)	405	22
7		(402)	(402)	415	13
8		(422)	(422)	425	3
9		(443)	(443)	436	(7)
10		(465)	(465)	447	(19)
11		(489)	(489)	458	(31)
12		(513)	(513)	469	(44)
13		(539)	(539)	481	(58)
14		(566)	(566)	493	(72)
15		(594)	(594)	506	(88)
16		(624)	(624)	518	(105)
17		(655)	(655)	531	(124)
18		(688)	(688)	544	(143)
19		(722)	(722)	558	(164)
20		(758)	(758)	572	(186)
				NPV =	($57,264)

Table C - 2
St. Ignace: EW15 Base Case

Capital Cost					**Cost**
Equipment Cost ($)					113,000
Installation Cost ($)					22,000
Other Capital Costs ($)					34,300
Total Capital Cost ($)					169,300
Plant Input Data					**Rate**
Total Net Capacity (kW)					66
Gross Annual Energy Production (kWh)					57,397
Energy Losses (%, kWh)				11.5%	6,601
Net Annual Energy Production (kWh)					50,796
Economic Input Data				**Rate**	**Escalation**
First Year O&M ($/kW)				30	5.0%
Avoided Energy Cost (¢/kWh)				4.20	2.5%
Discount Rate				8.0%	
DOE Funding Percentage				0%	

Year	Capital Cost ($)	O&M ($)	Total Cost ($)	Avoided Energy ($)	Net Cost ($)
0	(169,300)		(169,300)		(169,300)
1		0	0	2,133	2,133
2		(2,079)	(2,079)	2,187	108
3		(2,183)	(2,183)	2,241	59
4		(2,292)	(2,292)	2,297	5
5		(2,407)	(2,407)	2,355	(52)
6		(2,527)	(2,527)	2,414	(113)
7		(2,653)	(2,653)	2,474	(179)
8		(2,786)	(2,786)	2,536	(250)
9		(2,925)	(2,925)	2,599	(326)
10		(3,072)	(3,072)	2,664	(407)
11		(3,225)	(3,225)	2,731	(494)
12		(3,386)	(3,386)	2,799	(587)
13		(3,556)	(3,556)	2,869	(687)
14		(3,734)	(3,734)	2,941	(793)
15		(3,920)	(3,920)	3,015	(906)
16		(4,116)	(4,116)	3,090	(1,026)
17		(4,322)	(4,322)	3,167	(1,155)
18		(4,538)	(4,538)	3,246	(1,292)
19		(4,765)	(4,765)	3,327	(1,438)
20		(5,003)	(5,003)	3,411	(1,593)
				NPV =	($158,095)

Table C - 3
Manistique: Bergey Base Case

Capital Cost					**Cost**
Equipment Cost ($)					42,670
Installation Cost ($)					13,600
Other Capital Costs ($)					6,800
Total Capital Cost ($)					63,070
Plant Input Data					**Cost**
Total Net Capacity (kW)					10
Gross Annual Energy Production (kWh)					8,692
Losses (%, kWh)				8.3%	721
Net Annual Energy Production (kWh)					7,971
Economic Input Data				**Rate**	**Escalation**
First Year O&M ($/kW)				30	5.0%
Avoided Energy Cost (¢/kWh)				4.20	2.5%
Discount Rate (%)				8.0%	
DOE Funding Percentage				0%	

Year	Capital Cost ($)	O&M ($)	Total Cost ($)	Avoided Energy ($)	Net Cost ($)
0	(63,070)		(63,070)		(63,070)
1		0	0	335	335
2		0	0	343	343
3		0	0	352	352
4		0	0	361	361
5		0	0	370	370
6		(383)	(383)	379	(4)
7		(402)	(402)	388	(14)
8		(422)	(422)	398	(24)
9		(443)	(443)	408	(35)
10		(465)	(465)	418	(47)
11		(489)	(489)	429	(60)
12		(513)	(513)	439	(74)
13		(539)	(539)	450	(89)
14		(566)	(566)	461	(104)
15		(594)	(594)	473	(121)
16		(624)	(624)	485	(139)
17		(655)	(655)	497	(158)
18		(688)	(688)	509	(178)
19		(722)	(722)	522	(200)
20		(758)	(758)	535	(223)
				NPV =	($57,516)

Table C - 4
Manistique: EW15 Base Case

Capital Cost					**Cost**
Equipment Cost ($)					113,000
Installation Cost ($)					22,000
Other Capital Costs ($)					34,300
Total Capital Cost ($)					169,300
Plant Input Data					**Rate**
Total Net Capacity (kW)					66
Gross Annual Energy Production (kWh)					53,513
Energy Losses (%, kWh)				11.5%	6,154
Net Annual Energy Production (kWh)					47,359
Economic Input Data				**Rates**	**Escalation**
First Year O&M ($/kW)				30	5.0%
Avoided Energy Cost (¢/kWh)				4.20	2.5%
Discount Rate				8.0%	
DOE Funding Percentage				0%	
Year	Capital Cost ($)	O&M ($)	Total Cost ($)	Avoided Energy ($)	Net Cost ($)
0	(169,300)		(169,300)		(169,300)
1		0	0	1,989	1,989
2		(2,079)	(2,079)	2,039	(40)
3		(2,183)	(2,183)	2,090	(93)
4		(2,292)	(2,292)	2,142	(150)
5		(2,407)	(2,407)	2,196	(211)
6		(2,527)	(2,527)	2,250	(277)
7		(2,653)	(2,653)	2,307	(347)
8		(2,786)	(2,786)	2,364	(422)
9		(2,925)	(2,925)	2,423	(502)
10		(3,072)	(3,072)	2,484	(588)
11		(3,225)	(3,225)	2,546	(679)
12		(3,386)	(3,386)	2,610	(777)
13		(3,556)	(3,556)	2,675	(881)
14		(3,734)	(3,734)	2,742	(992)
15		(3,920)	(3,920)	2,811	(1,110)
16		(4,116)	(4,116)	2,881	(1,235)
17		(4,322)	(4,322)	2,953	(1,369)
18		(4,538)	(4,538)	3,027	(1,512)
19		(4,765)	(4,765)	3,102	(1,663)
20		(5,003)	(5,003)	3,180	(1,824)
				NPV =	($159,671)

Appendix D – Sensitivity-Case Models

Table D - 1
St. Ignace: Bergey - 100% DOE Equipment Grant

Capital Cost					**Cost**
Equipment Cost ($)					42,670
Installation Cost ($)					13,600
Other Capital Costs ($)					6,800
Total Capital Cost ($)					63,070
Plant Input Data					**Rate**
Total Net Capacity (kW)					10
Gross Annual Energy Production (kWh)					9,290
Losses (%, kWh)				8.3%	771
Net Annual Energy Production (kWh)					8,519
Economic Input Data				**Rate**	**Escalation**
First Year O&M ($/kW)				30	5.0%
Avoided Energy Cost (¢/kWh)				4.20	2.5%
Discount Rate				8.0%	
DOE Funding Percentage				100%	

Year	Capital Cost ($)	O&M ($)	Total Cost ($)	Avoided Energy ($)	Net Cost ($)
0	(20,400)		(20,400)		(20,400)
1		0	0	358	358
2		0	0	367	367
3		0	0	376	376
4		0	0	385	385
5		0	0	395	395
6		(383)	(383)	405	22
7		(402)	(402)	415	13
8		(422)	(422)	425	3
9		(443)	(443)	436	(7)
10		(465)	(465)	447	(19)
11		(489)	(489)	458	(31)
12		(513)	(513)	469	(44)
13		(539)	(539)	481	(58)
14		(566)	(566)	493	(72)
15		(594)	(594)	506	(88)
16		(624)	(624)	518	(105)
17		(655)	(655)	531	(124)
18		(688)	(688)	544	(143)
19		(722)	(722)	558	(164)
20		(758)	(758)	572	(186)
				NPV =	($17,755)

Table D - 2
St. Ignace: EW15 - 100% DOE Equipment Grant

Capital Cost		**Cost**
Equipment Cost ($)		113,000
Installation Cost ($)		22,000
Other Capital Costs ($)		34,300
Total Capital Cost ($)		169,300
Plant Input Data		**Rate**
Total Net Capacity (kW)		66
Gross Annual Energy Production (kWh)		57,397
Energy Losses (%, kWh)	11.5%	6,601
Net Annual Energy Production (kWh)		50,796

Economic Input Data	**Rate**	**Escalation**
First Year O&M ($/kW)	30	5.0%
Avoided Energy Cost (¢/kWh)	4.20	2.5%
Discount Rate	8.0%	
DOE Funding Percentage	100%	

Year	Capital Cost ($)	O&M ($)	Total Cost ($)	Avoided Energy ($)	Net Cost ($)
0	(56,300)		(56,300)		(56,300)
1		0	0	2,133	2,133
2		(2,079)	(2,079)	2,187	108
3		(2,183)	(2,183)	2,241	59
4		(2,292)	(2,292)	2,297	5
5		(2,407)	(2,407)	2,355	(52)
6		(2,527)	(2,527)	2,414	(113)
7		(2,653)	(2,653)	2,474	(179)
8		(2,786)	(2,786)	2,536	(250)
9		(2,925)	(2,925)	2,599	(326)
10		(3,072)	(3,072)	2,664	(407)
11		(3,225)	(3,225)	2,731	(494)
12		(3,386)	(3,386)	2,799	(587)
13		(3,556)	(3,556)	2,869	(687)
14		(3,734)	(3,734)	2,941	(793)
15		(3,920)	(3,920)	3,015	(906)
16		(4,116)	(4,116)	3,090	(1,026)
17		(4,322)	(4,322)	3,167	(1,155)
18		(4,538)	(4,538)	3,246	(1,292)
19		(4,765)	(4,765)	3,327	(1,438)
20		(5,003)	(5,003)	3,411	(1,593)
				NPV =	($53,465)

Table D - 3
Manistique: Bergey - 100% DOE Equipment Grant

Capital Cost					**Cost**
Equipment Cost ($)					42,670
Installation Cost ($)					13,600
Other Capital Costs ($)					6,800
Total Capital Cost ($)					63,070
Plant Input Data					**Cost**
Total Net Capacity (kW)					10
Gross Annual Energy Production (kWh)					8,692
Losses (%, kWh)				8.3%	721
Net Annual Energy Production (kWh)					7,971
Economic Input Data				**Rate**	**Escalation**
First Year O&M ($/kW)				30	5.0%
Avoided Energy Cost (¢/kWh)				4.20	2.5%
Discount Rate (%)				8.0%	
DOE Funding Percentage				100%	

Year	Capital Cost ($)	O&M ($)	Total Cost ($)	Avoided Energy ($)	Net Cost ($)
0	(20,400)		(20,400)		(20,400)
1		0	0	335	335
2		0	0	343	343
3		0	0	352	352
4		0	0	361	361
5		0	0	370	370
6		(383)	(383)	379	(4)
7		(402)	(402)	388	(14)
8		(422)	(422)	398	(24)
9		(443)	(443)	408	(35)
10		(465)	(465)	418	(47)
11		(489)	(489)	429	(60)
12		(513)	(513)	439	(74)
13		(539)	(539)	450	(89)
14		(566)	(566)	461	(104)
15		(594)	(594)	473	(121)
16		(624)	(624)	485	(139)
17		(655)	(655)	497	(158)
18		(688)	(688)	509	(178)
19		(722)	(722)	522	(200)
20		(758)	(758)	535	(223)
				NPV =	($18,006)

Table D - 4
Manistique: EW15 - 100% DOE Equipment Grant

Capital Cost					**Cost**
Equipment Cost ($)					113,000
Installation Cost ($)					22,000
Other Capital Costs ($)					34,300
Total Capital Cost ($)					169,300
Plant Input Data					**Rate**
Total Net Capacity (kW)					66
Gross Annual Energy Production (kWh)					53,513
Energy Losses (%, kWh)				11.5%	6,154
Net Annual Energy Production (kWh)					47,359
Economic Input Data				**Rates**	**Escalation**
First Year O&M ($/kW)				30	5.0%
Avoided Energy Cost (¢/kWh)				4.20	2.5%
Discount Rate				8.0%	
DOE Funding Percentage				100%	

Year	Capital Cost ($)	O&M ($)	Total Cost ($)	Avoided Energy ($)	Net Cost ($)
0	(56,300)		(56,300)		(56,300)
1		0	0	1,989	1,989
2		(2,079)	(2,079)	2,039	(40)
3		(2,183)	(2,183)	2,090	(93)
4		(2,292)	(2,292)	2,142	(150)
5		(2,407)	(2,407)	2,196	(211)
6		(2,527)	(2,527)	2,250	(277)
7		(2,653)	(2,653)	2,307	(347)
8		(2,786)	(2,786)	2,364	(422)
9		(2,925)	(2,925)	2,423	(502)
10		(3,072)	(3,072)	2,484	(588)
11		(3,225)	(3,225)	2,546	(679)
12		(3,386)	(3,386)	2,610	(777)
13		(3,556)	(3,556)	2,675	(881)
14		(3,734)	(3,734)	2,742	(992)
15		(3,920)	(3,920)	2,811	(1,110)
16		(4,116)	(4,116)	2,881	(1,235)
17		(4,322)	(4,322)	2,953	(1,369)
18		(4,538)	(4,538)	3,027	(1,512)
19		(4,765)	(4,765)	3,102	(1,663)
20		(5,003)	(5,003)	3,180	(1,824)
				NPV =	($55,041)