The Grand Traverse Band of Ottawa and Chippewa Indians

2605 N. West Bay Shore Drive • Peshawbestown, MI 49682 • (231) 534-7750

March 31, 2009

Lizana K. Pierce
Golden Field Office
1617 Cole Blvd
Golden, CO 80401-3305

SUBJECT: FINAL SCIENTIFIC REPORT ID# DE-FG36-05GO15182

Enclosed please find the Feasibility Study in Wind, Biomass and Solar conducted by the Grand Traverse Band of Ottawa & Chippewa Indians. This document constitutes the final deliverables of the scientific report under our funding agreement. I have reviewed the report and it is now ready for submission to your office.

Should your office have any questions or need any additional information, please feel free to contact me at the above address, or by calling 231.534.7136.

Sincerely,

Jolanda Murphy
Interim Tribal Manager

JM/Jl

Enclosures

Cc Internal File 4802
Project File 4802
Division File II
Accounting File

DOE F 241.3
(2-01) p. 1 of 4

ANNOUNCEMENT

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Scientific and Technical Information (STI) For Financial Assistance Recipients and Non-M&O/M&I Contractors

OMB Control No. 1910-1400

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1. REPORT/PRODUCT NUMBER(s)

2. DOE AWARD/CONTRACT NUMBER(s)
DE-FG36-05GO-15182

3. OTHER IDENTIFYING NUMBER(s)

B. Recipient/Contractor

Grand Traverse Band of Ottawa & Chippewa Indians

C. STI Product Title

Grand Traverse Band Renewable Energy Feasibility Study in Wind, Biomass and Solar

D. Author(s)

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Steve Smiley, Principle Investigator
Bob Gough – Project Advisor & Cost Sharing Partner
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E. STI Product Issue Date/Date of Publication

12/31/2008 (mm/dd/yyyy)

F. STI Product Type *(Select only one)*

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☒ *Final* ☐ *Other (specify)* ______

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c. VOLUME ______ *d. ISSUE* ______
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H. Sponsoring DOE Program Office

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Wind, Renewable Energy, feasibility study, biomass, solar, Grand Traverse Band, GTB
Keywords Grand Traverse Band, GTB, Wind, Renewable Energy, feasibility study, biomass, solar

J. Description/Abstract

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L. Recipient/Contractor Point of Contact *Contact for additional information (contact or organization name to be included in published citations and who would receive any external questions about the content of the STI Product or the research contained therein)*

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Grand Traverse Band of Ottawa & Chippewa Indians
Organization

ANNOUNCEMENT

UNITED STATES DEPARTMENT OF ENERGY (DOE)
Scientific and Technical Information (STI) For Financial Assistance Recipients and Non-M&O/M&I Contractors

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Grand Traverse Band
Renewable Energy Feasibility Study
in Wind, Biomass and Solar

December 2008

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US Department of Energy: Tribal Energy Program

Final Technical Report

Award Number:	DE-FG36—05GO15182
Recipient Organization:	Grand Traverse Band of Ottawa and Chippewa Indians
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DOE Project Officer:	Lizana K. Pierce, lizana.pierce@go.doe.gov
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Technical Report Executive Summary

The goal of this strategic planning energy feasibility study was to outline what is required for the Grand Traverse Band of Ottawa and Chippewa Indians (GTB or Tribe) to provide itself with one hundred percent of its energy needs from renewable resources. In addition, comprehensive economic and environmental impacts were to be considered. In accomplishing this goal Tribal energy consumption was identified, including the nature and sources of energy, fuel types, quantities and costs. Studies were conducted to determine the nature of the renewable energy resources, especially the most common and cost effective resources in the climate and lands of the Grand Traverse Band. Once the renewable resources were identified and quantified then various technologies of known cost, availability and reliability were examined for application to the Tribal residences, public and commercial facilities. The theme of this strategic energy plan, used in the title of the educational brochure produced as part of the project, is “The Path to Energy Sovereignty”

The following paragraphs address the specific questions required for the technical report. This first discussion relates to “how the research adds to the understanding of the area investigated.”

This research adds significantly to the area investigated. First, it identifies and quantifies the renewable resources available to the Grand Traverse Band in its members region. This is the first comprehensive quantification of renewable resources in one document and body of work for the Tribe. While the solar, wind and biomass resource data has been available in general terms, the detailed nature and availability of these resources has been refined, especially demonstrated in the accomplishment of the site specific and regional wind study completed in cooperation with the local municipal electric utility. Next, the cost of renewable energy, with both fuel costs and most recent practical and well tested updated renewable energy technologies has been identified. Finally, the energy consumption of the Tribe has been quantified so there is a reference bench-mark to determine the energy requirements of proposed renewable energy sources and technologies.

Next, the technical effectiveness and economic feasibility of the areas studied were demonstrated. All of the renewable energy technologies proposed have been based on existing, recently implemented technologies that are in operation with established successful performance. Site visits and tours of these technologies were made including wind turbines, biomass heating and power plants, solar thermal and solar electric systems. No untested or unconventional renewable energy technologies were considered in the economic feasibility studies. The results of the economic feasibility studies indicate a wide range of costs from a high cost with solar electric and small wind power systems to a lower and more competitive cost for solar thermal, larger scale biomass heating and electric power and large scale wind power. Cost curves were made

comparing the renewable resources and technologies. The project is a benefit to the public because many of the renewable technologies demonstrated, at a larger community scale, are shown to be cost effective, providing long-term energy security, fixed and/or reduced costs, with significant environmental and economic benefits.
The work accomplishments met the goals and objective of the project. These accomplishments are detail in the summary of the project activities below

Project Summary

A summary of the GTB Tribe area and membership is as follows:

- 3,988 Members (as of 2006)
- 2,370 Acres – Checkerboard
- Six-County Service Area (80 miles x 80 miles)
- Commercial Economic Development: 2 Casinos--with hotels, golf & spa resort (424 Rooms), gas station, etc.
- Government and public: Administration, Housing, Medicine Lodge, Strong Heart Center, Day Care, etc.

The GTB energy use (including the new, 2008 Turtle Creek Casino Hotel) is summarized as follows:

- Total Cost: $6 million/year
- Electric Cost: $3 million/year
- Natural Gas Cost: $2.4 million/year
- LP Gas Cost: $600,000 per year
- Electric: 42 million kilowatt-hours per year
- Natural Gas: 2 million ccf per year
- LP Gas: 435,000 gallons per year
- Peak Electric KW: 5,700 KW (Commercial, Government and public facilities)
- Average Electric KW: 4,800 kW for entire Tribe

In addition to these fossil energy fuels, many Tribal members use cord wood in wood stoves for space heating. Cord wood use has not been quantified but would amount to approximately 200 to 300 homes. This is based upon an assumption of 25% cord wood utilization in the estimated 1,138 Tribal member homes, assuming 3.5 persons per home.

The primary renewable resources in the GTB region (see figure 1), at 45 degree north latitude, on the eastern side of Lake Michigan, include wind, biomass, and solar energy. There are no known geothermal resources, wave power on the great lakes is untested, and hydroelectric power is very limited in availability with small, low-head creeks.

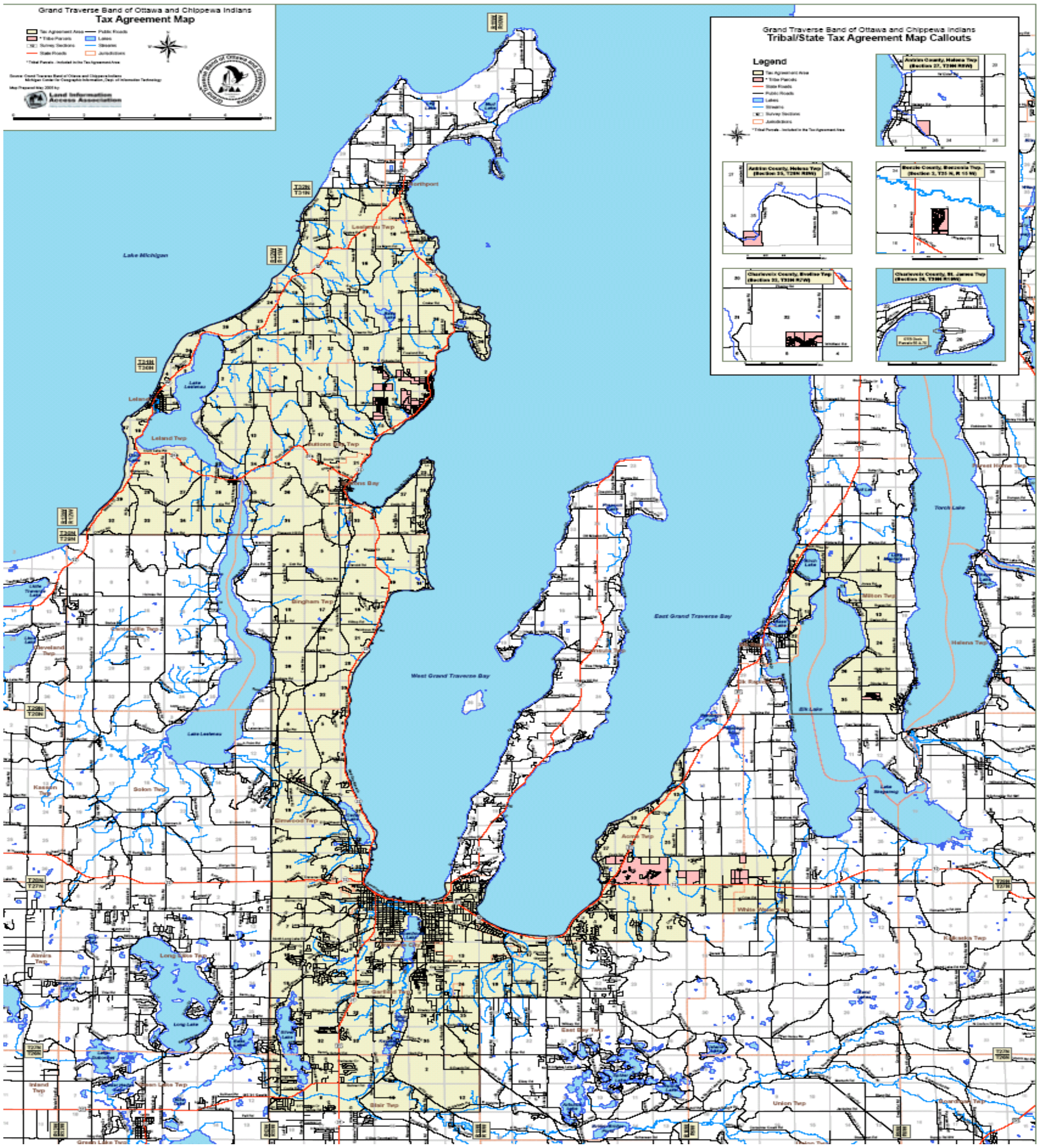

Figure 1. GTB Regional Map (GTB Lands under ownership in pink)

Detailed wind power studies were completed to characterize both specific wind sites at the largest energy consuming facilities, and to provide a general wind resource assessment for outlying GTB communities. Both small and large commercial wind energy was analyzed.

Solar energy was determined by applying the US Department of Energy, National Renewable Energy Laboratory government regional solar insolation data to the land areas under control by the Tribe. Then both solar thermal and solar electric (photovoltaic) systems were examined from small residential to larger scale applications.

Biomass availability was determined based on supplies in the GTB region, primarily consisting of wood chips produced from forestry waste, farm wood lots, tree plantations and landscaping. Estimates made of sustainable levels of biomass determined that biomass availability is very significant. Other biomass resources such as straw and animal waste from farms is yet limited in availability and distribution. Whole log firewood is commonly available for residential wood stoves, and typically comes from thinning for tree growth improvement and landscaping. Predominant species available for firewood include sugar and silver maple, birch, ash and beech. Red pine and jack pine plantations are common but this wood is not typically used for firewood due to its lower energy content in comparison to the hardwoods. Pine is more commonly used in larger scale biomass electric generation facilities ranging in size from 10 to 30 mega-watts (MW) electric. During harvesting, tops and branches are typically chipped for the biomass energy industry. There is a well established market and distribution system for wood chips due to regional biomass steam electric power plants that are operating in the 10 to 30 MW capacity range. Based upon interviews with three wood chip haulers in mid-Michigan, tractor-trailer trucks haul wood chips in loads of 30 to 40 tons. The cost is roughly $20 to $25 per ton with prices seen as low as $18 per ton and up to $26 per ton. With the standard assumption of 8,500 BTU per lb dry wood chip basis and 4500 BTU per lb wet basis, then at 2000 lbs/ton X 4500 BTU = 9 million BTU per ton. With a price of $22.50 per ton, then dividing the price per ton by the energy content in MMBTU, we arrive at a cost = $2.50 per MMBTU ($22.50/9 MMBTU). This biomass is the cheapest combustion energy fuel, cost compared to $10 to $12 per MMBTU for natural gas. Other than free renewable energy such as wind and sun, wood chips are the cheapest utilized fuel on the market.

Transport vehicle energy was not part of the scope of this study and therefore bio-fuels such as corn ethanol, bio-gas or pure plant oil were not considered. Additional studies are recommended for bio-fuel vehicles and electric vehicles. It may be feasible to establish a fleet of pure electric vehicles and or plug-in-hybrid vehicles based upon commercial wind power based battery systems with off-peak electric charging.

The following portion of this executive summary describes the results and conclusions of this strategic energy planning study.

Energy Demand

The following table shows a breakdown of energy use for the Tribe, exclusive of transportation fuels and cord wood used for heating homes.

Grand Traverse Band Breakdown of GTB Energy Use Year 2005 (w/ 2008 adj)	Electric kW-hrs/yr	Electric Elec Cost / Yr	Natural Gas CCF's/yr	Natural Gas Cost/yr	LP Gas Gal/yr	LP Gas Cost/yr	Total Cost	Percent
Peshawbestown (Commercial/Public)	5,891,286	$ 388,802	144,624	$ 173,549	834	$ 1,084	$ 563,434	9.3%
Peshawbestown Residential W	842,400	$ 75,816	98,150	$ 117,779	39,167	$ 54,834	$ 248,430	4.1%
Peshawbestown Residential E	770,400	$ 69,336	123,553	$ 148,263			$ 217,599	3.6%
Turtle Creek Casino (Comm/Public)	15,513,551	$ 1,035,664	376,024	$ 451,229	-	$ -	$ 1,486,893	24.5%
GT Resort & Spa	12,545,244	$ 878,167	528,570	$ 634,284			$ 1,512,451	25.0%
Traverse City (Commercial/Public)	453,760	$ 40,838	6,954	$ 8,345			$ 49,183	0.8%
Benzie (Admin)	60,585	$ 5,950			5,640	$ 7,896	$ 13,846	0.2%
Benzie (Residential)	381,600	$ 34,344	-	$ -	64,871	$ 90,819	$ 125,163	2.1%
Charlevoix (Admin)	30,560	$ 2,576			3,437	$ 4,812	$ 7,388	0.1%
Charlevoix (Residential)	266,400	$ 23,976	-	$ -	45,287	$ 63,402	$ 87,378	1.4%
Antrim (Residential)	187,200	$ 16,848	-	$ -	31,824	$ 44,553	$ 61,401	1.0%
Balance of Residential	5,745,600	$ 517,104	691,088	$ 829,306	244,184	$ 341,858	$ 1,688,268	27.9%
	42,688,586	$ 3,089,421	1,968,962	$ 2,362,755	435,245	$ 609,259	$ 6,061,436	100.0%
		Electric		Natural Gas		LP Gas		
Cost per MMBTU		$ 21.20	$/MMBTU	$ 12.00	$/MMBTU	$ 14.89	$/MMBTU	

Table 1. Energy Consumption

From this table it can be seen that the largest portion of energy costs come from the dispersed residences and commercial and public facilities. The single largest category is the member residences totaling 27.9%, then the Grand Traverse Resort and Spa with 25%, which includes a large 16 story hotel resort complex, and the new Turtle Creek Casino Hotel with 24.5%. The Tribal government facilities and Leelanau Sands Casino and hotel complex in Peshawbestown are next with 9.3%.

Comparisons with electricity costs and space/water heating (thermal energy) show they are roughly equal with 51% for electricity and 49% for space and water heating (natural gas and LP gas combined = 49% NG 39% + LP 10%) as shown in Figure 2 below.

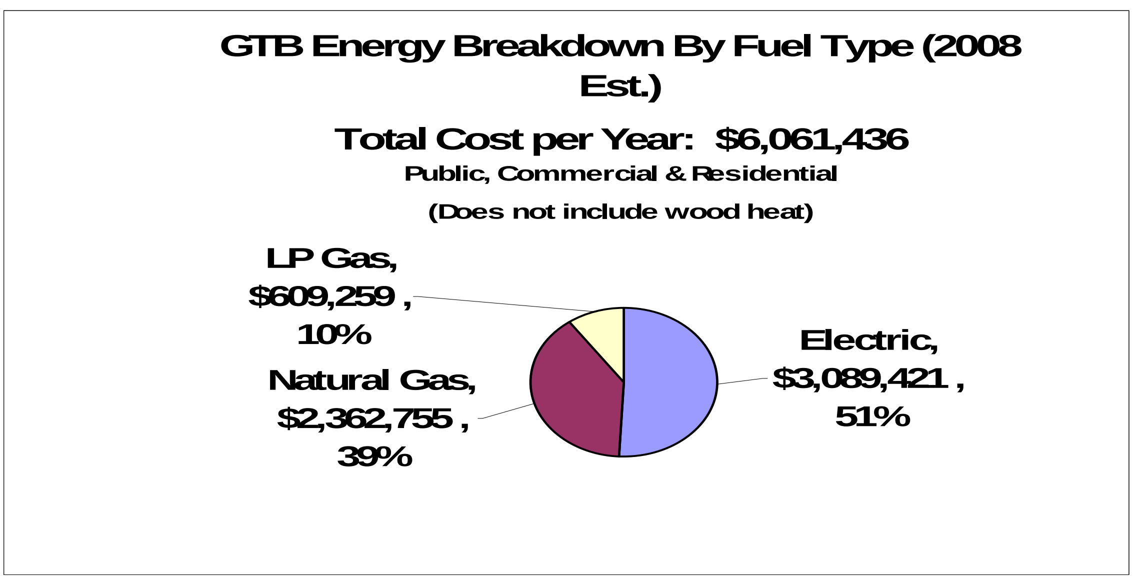

Figure 2. Energy Consumption - Fuel Type

The following pie charts (Figures 3 - 6) clearly illustrate the nature and costs of energy use at the Tribe.

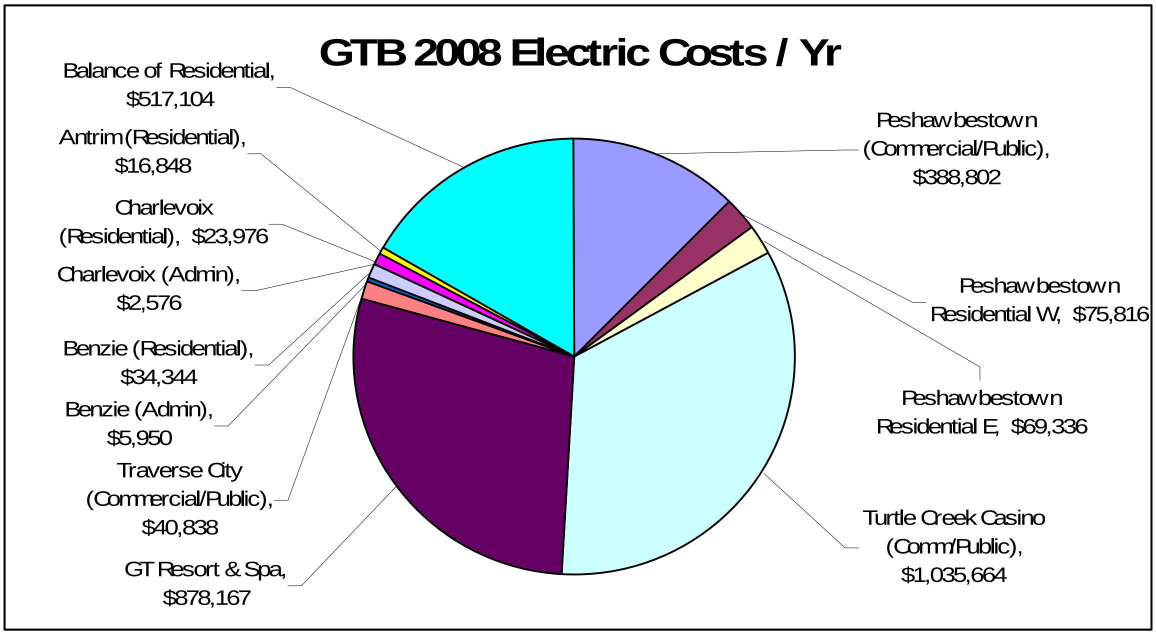

Figure 3 Energy Consumption – Electric Costs

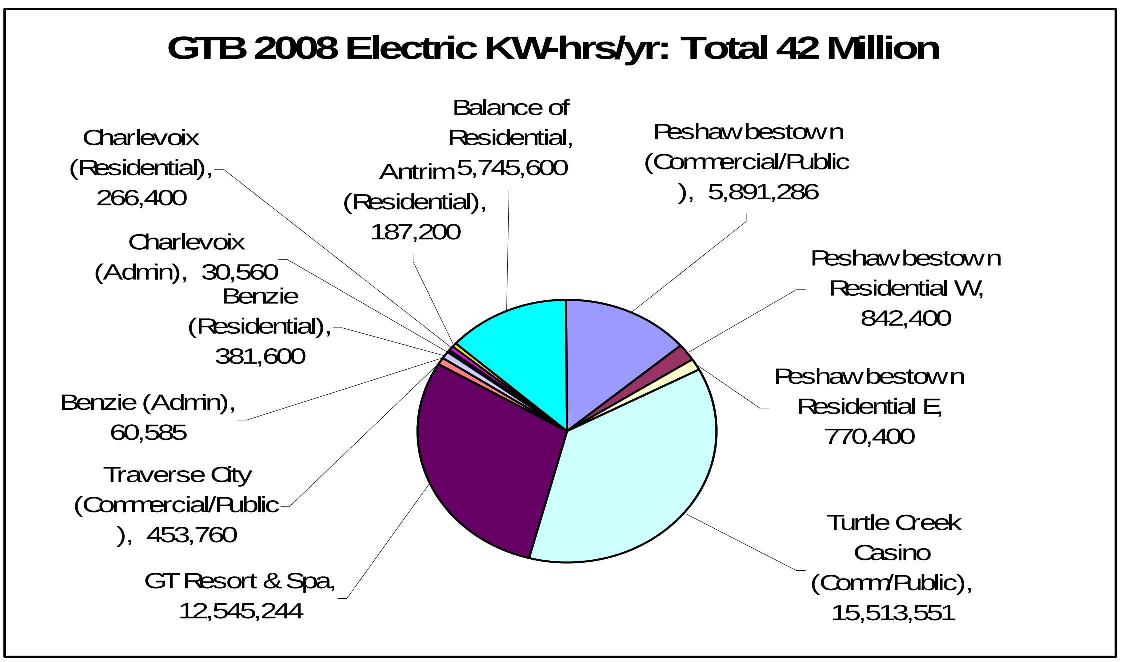

Figure 4. Energy Consumption – Electric KW-hrs/yr

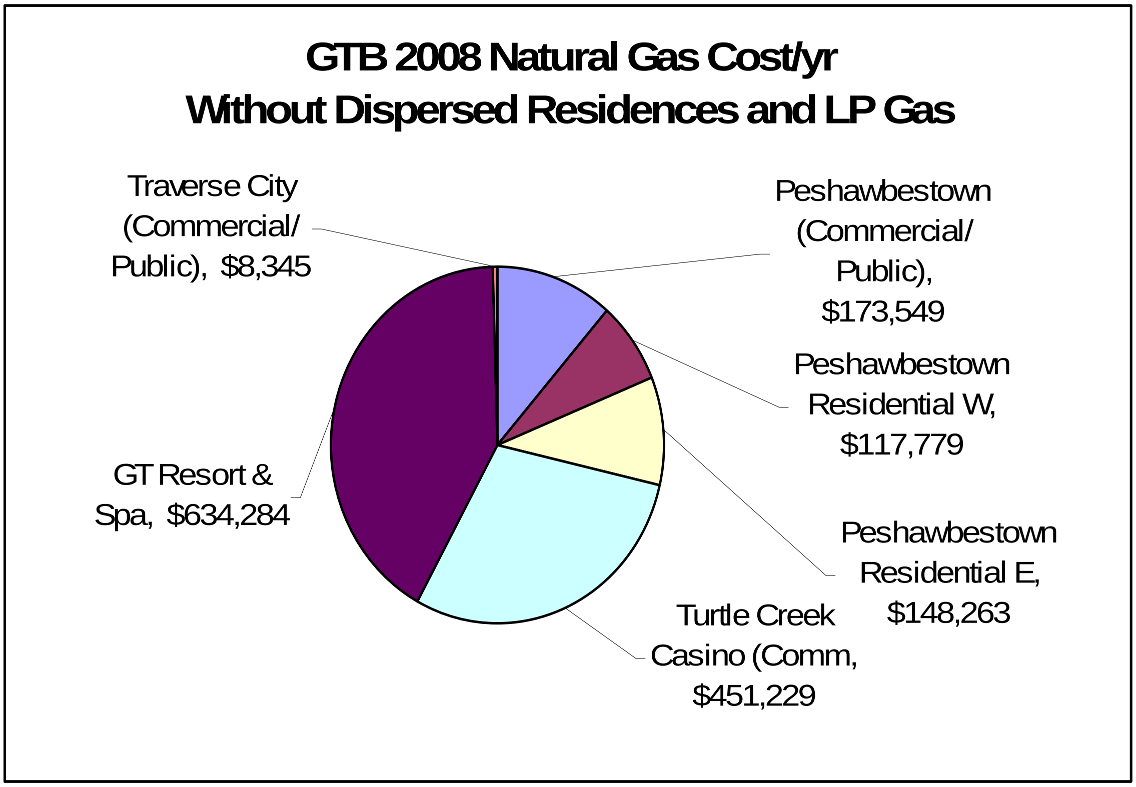

Figure 5. Energy Consumption –Natural Gas Cost/yr without Dispersed Residences and LP Gas

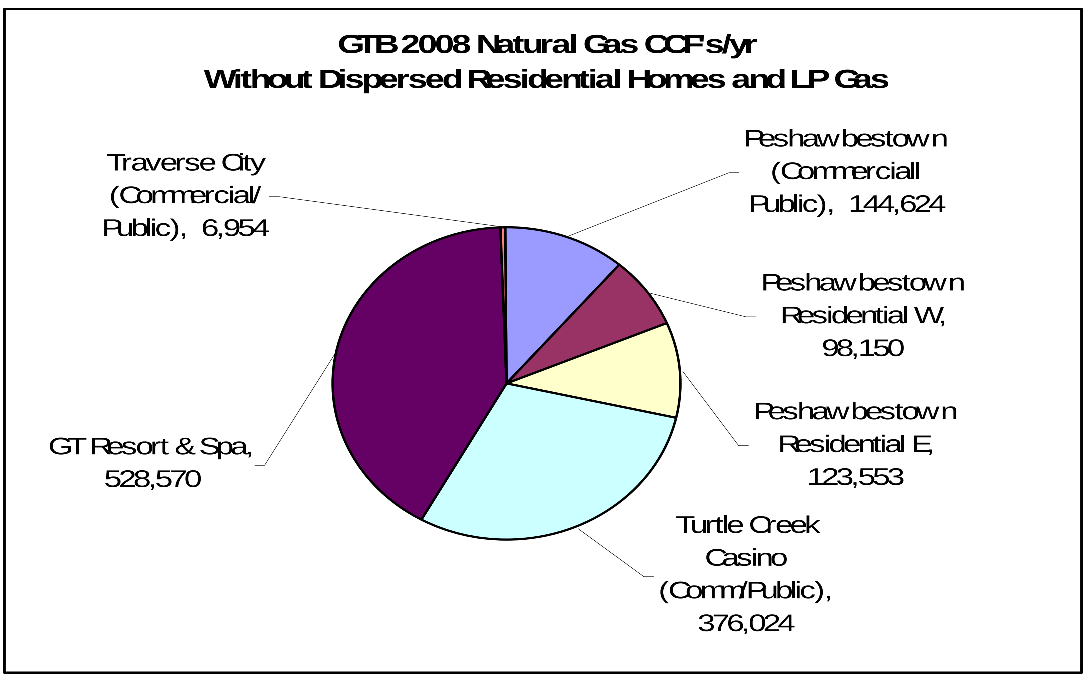

Figure 6. Energy Consumption –Natural Gas Cost/yr without Dispersed Residential Homes and LP Gas

This energy consumption profile provides the basis for determining the scale and nature of which types of renewable energy systems, electric or thermal, may be most appropriate to meet the energy needs of the Tribe. Roughly half of the Tribes' energy needs are thermal, and half electric. However, from Table 1 it can be seen that for residential energy needs thermal energy for space and water heating are a priority (residential heating bills are higher than electric bills), whereas for the commercial and public facilities, electricity makes up the larger portion of the energy requirements requiring more than two-thirds of the energy budget for those facilities.

Roughly 50% of Tribal energy costs are associated with the Grand Traverse Resort and Turtle Creek facilities resulting from the 2008 expansion of Turtle Creek. Consequently, on the commercial side of the Tribe, it is a priority to determine how to maximize the utilization of the renewable resources of the Tribe. This is also where significant economies of scale can be achieved with larger scale wind turbines, biomass heating and electric plants (combined heat and power or "CHP") and solar installations. Cost analysis shows the larger the renewable energy system the lower the cost for the energy generated. Also we find better economics if the energy systems are installed close to the energy "load" center, and when energy consumption is distributed more evenly over the year such as at the casinos. From the stand-point of the whole Tribal economic picture, the GT Resort / Turtle Creek area can provide the most renewable energy generation, energy revenues and cost savings to the Tribe.

Public facilities and housing districts provide the next best renewable energy opportunities where smaller biomass district heating plants can be installed in conjunction with home or neighborhood solar hot water heating systems. Such opportunities include the residential and administrative facilities in Peshawbestown, Charlevoix and Benzie. Finally, the dispersed residential homes will require a mix of solar energy (both thermal and electric), some small wind, biomass (cord wood, wood pellets, etc.) and energy efficiency applications.

Determining the best residential, commercial and public facility renewable energy system balance, within budget constraints, to maximize the benefits to the whole Tribe, is the primary challenge for the Tribal leadership.

Wind and Solar Energy Resources

The following tables and charts (Figure 7) derived from the study conducted by the Tripod Wind Energy Aps for Traverse City Light & Power (Attachment A), illustrate the character of the wind resources measured at the Grand Traverse Resort site with a 50 meter meteorological ("met") tower. This data set is from wind speed and direction sensors measured at 50.5 meters (165 ft). Three levels of wind speed measurements were taken, 30, 40 and 50.5 meters, in order to determine shear factors for projecting wind energy at higher heights. All of the wind data was analyzed to confirm sensor reliability and an historic correlation was made based on nearby long-term wind data collected at the Traverse City airport in order to make adjusted annual average wind resource projections. One hundred percent (100%) of the data was recovered for an entire year at the GT Resort met tower.

The Weibull A and k parameters and mean wind speed for the available measuring periods are shown below.

	Weibull A	Weibull k	Mean Wind Speed
GT Resort, 1 year, 50.5 m	6.4 m/s	2.31	5.6 m/s
Long Lake, 9 months, 50.5 m	6.6 m/s	2.63	5.9 m/s
TVC, 9 years, 10 m	3.8 m/s	1.69	3.4 m/s
Pellston, 6 years, 10 m	4.0 m/s	1.30	3.7 m/s

Please note that the Weibull parameters and mean wind speeds must not be compared directly, as neither the measuring periods nor the measuring heights are not identical.

4.2 Wind Direction Distribution

The wind direction distribution is shown for the GT Resort data only, as the Long Lake measurement covers less than one year and as the wind direction data from TVC and Pellston are incomplete. Figure 11 shows the wind rose (direction in per cent of time) and figure 12 the energy rose (direction in per cent of energy) of the distribution

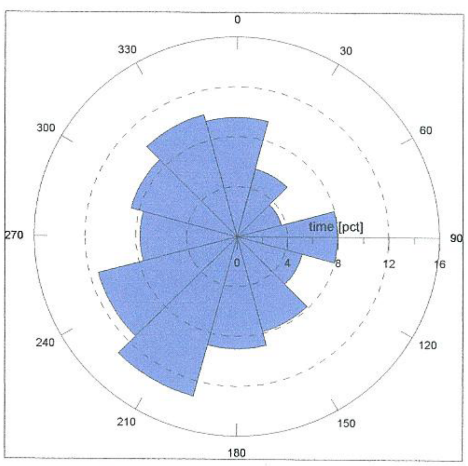

Figure 11 Wind rose at GT Resort

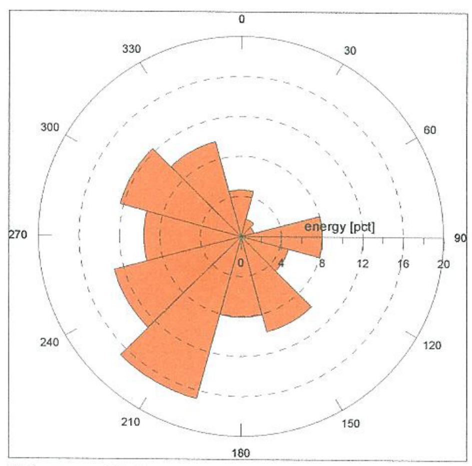

Figure 12 Energy rose at GT Resort

In figure 11 and 12 it can be seen that the prevailing wind direction (time as well as energy) at GT Resort is southwest.

4.3 Monthly and Diurnal Variations

The figures 13-15 show the monthly variations for the GT Resort, TVC and Pellston measurements (Long Lake covers 9 months only).

The figures show a clear seasonal variation, with the highest wind speeds during winter and lowest wind speeds during summer.

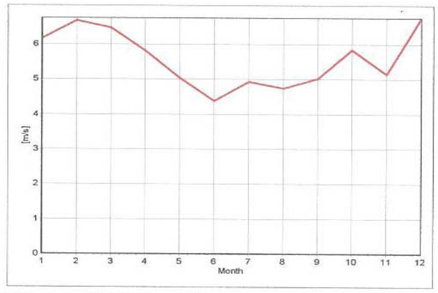

Figure 13 Monthly mean wind speeds at GT Resort (June 2006 - May 2007)

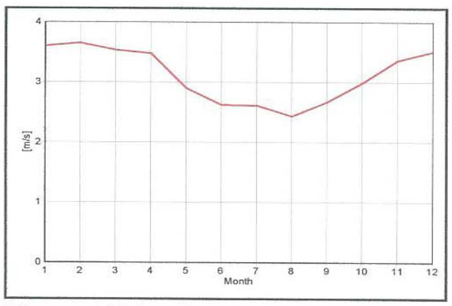

Figure 14 Monthly mean wind speeds at TVC (1998-2007)

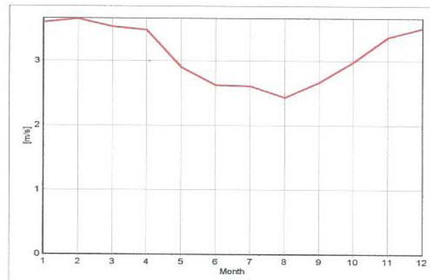

Figure 15 Monthly mean wind speeds at Pellston (2000-2007)

The diurnal variations in the wind speed is shown in figures 16-19 for the four measurements.

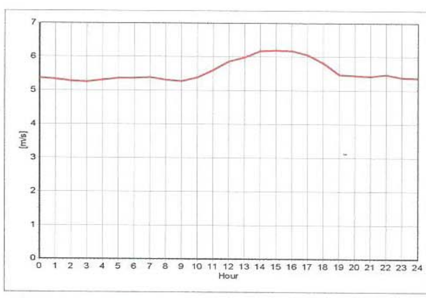

Figure 16 Diurnal wind speed variation at GT Resort

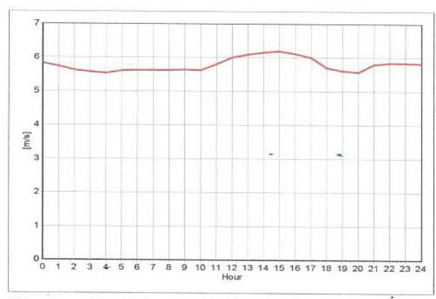

Figure 17 Diurnal wind speed variation at Long Lake

Figure 7: GT Resort Wind Data

From the wind data collected shear factors were determined and wind energy density calculations made for common large commercial wind turbines in the one to two mega-watt peak capacity range. The Figure 8 graph shows the expected average daily energy produced by one square meter of swept area from a typical large commercial wind turbine. This amount, varying by month, has been determined to range from roughly one kilowatt-hr (kW-hr) per day in the lowest wind month (August) to 2.4 kilowatt-hours per day per square meter swept area in the highest wind month. The annual average will exceed 700 kW-hrs per square meter (10.6 sq. ft.) swept area at a hub height of 80 to 100 meters. For small windmills, much lower in height, we can expect roughly one-half of this energy density, and as a result, much higher wind energy costs.

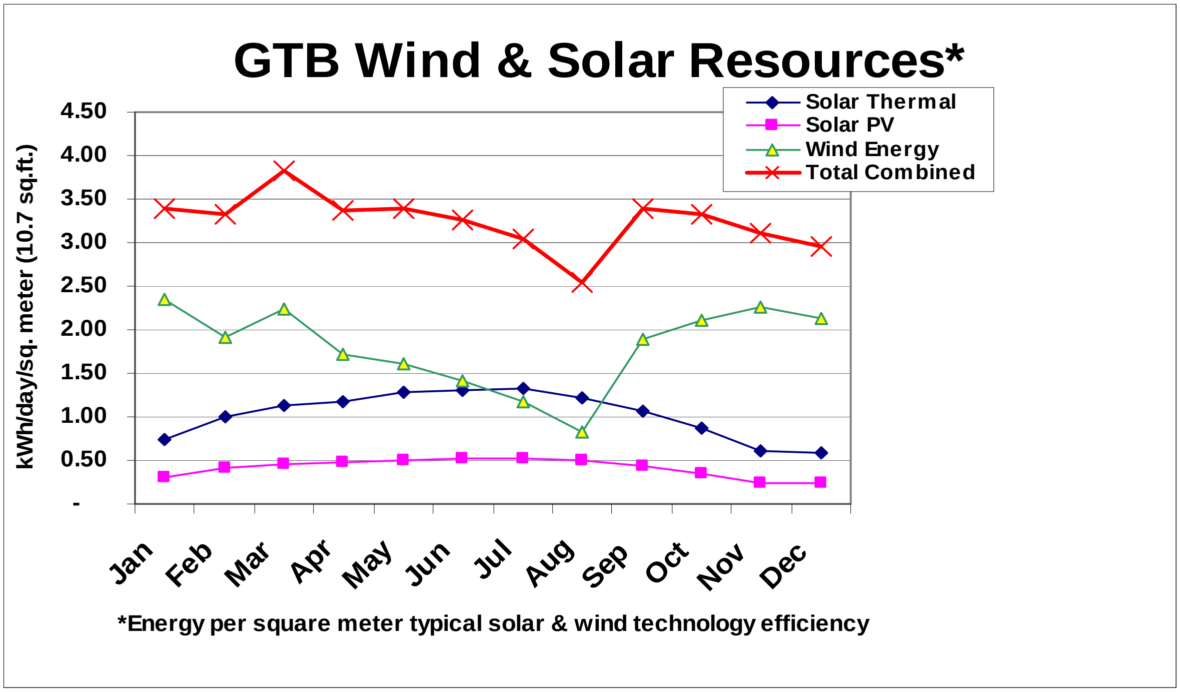

Figure 8 GTB Wind & Solar Resources Graph

Wind energy resources are roughly twice as high in the fall and winter months than in the summer months, with August being the lowest month. Combining the high summer solar resources with the low summer wind, and vice versus provides an annual balance of these resources, as shown in the top (red) line in Figure 8.

Solar resources are shown in Figure 8, with average per day output per square meters (10.6 sq. ft.) of panel area for each month, calculated for both solar electric and solar thermal (hot water) systems using present available technologies and efficiencies. As shown, solar hot water heating systems are much more efficient in converting incoming solar radiation to heat than solar electric systems are converting solar radiation to electricity. As shown in the graph there is approximately twice as much solar energy during the summer months than the winter months.

From this data, calculations can be made to estimate the necessary rotor swept area of windmills or solar panel area, on average, required to generate the required renewable energy. For example, from this we can see that twelve, 82 meter rotor diameter wind turbines, each with a swept area of 5,280 sq. meters, on tall towers, would generate 100% of the Tribes net annual electric consumption, including residential, public and commercial facilities, of 42 million kW-hours per year.

With standard solar photovoltaic panels, to generate the net annual electricity consumption of 42 million kWhrs per year (ground mounted with 50% spacing), the land area required will be 124 acres, or 5% of the land owned by the Tribe.

Biomass Resources

Michigan has a forest fiber surplus. Forest growth minus harvest is number #1 in the USA. Michigan forests are a renewable asset, which is currently harvested at less than 40 percent of its annual growth. In the Northern Lower Peninsula and Upper Peninsula forest growth is 3% greater than current forest inventory. Harvest is 2/3rds of growth in recent years. Beyond these inventory numbers, in the last couple of years two forest product plants closed. These plant closings, in Gaylord and Muskegon, Michigan made available an additional 1.7 million tons of wood in 2006, dropping market prices to $14/ton.

Most wood residue available for power and heat generation is from lumbering activities, some building materials waste and whole tree chips, with sources depending on price and availability. Fuel wood is being harvested green in combination with logging, thinning, commercial forest management, and timber stand improvement, and is not dried in the forest. Therefore with both hardwoods and softwoods, high moisture content, in the 40-50% range, is the norm.

In addition there is a significant diffuse supply of biomass consisting of landscaping, storm damage, tree trimming, and utility line maintenance. Diseased trees resulting from spruce bud worm, oak wilt, beech scale, emerald ash bore control and public works tree removal provide additional fuel.

With some small financial incentives this resource may be considerable. Combined heat and power plants utilizing wood residues from forest harvest operations, landscaping, and demolition are all abundant in Michigan . Semi-truck trailer delivery is most common for wood chips. In 2006 green wood chips were $14/ton delivered. This is unsustainable for logging firms. A price of $22/ton delivered wood chips is recommended, with $25 per ton can be used as a conservative pricing assumption.

Shipping biomass with water transportation across Lake Michigan from the Upper Peninsula or Wisconsin is at $24 - $32.50/ton, plus the cost of harvest, dock loading/unloading and increased storage. The total cost for water shipping nearly doubles the price available with truck transportation.

The combination of working conditions, weather, holidays and truck weight restrictions will necessitate provisions for seasonal storage of a minimum 14 days. Off site storage at various wood haulers facilities will provide year around fuel availability. Biomass fuel storage at a biomass power plant should be plus or minus 7 days varying with seasonal heating loads and electrical generation loads.

Wood ash handling is an essential part of a biomass plant. Wood ash, at 1% to 2% by weight, for the larger projected biomass plant in this study, equals 1 to 2 tons per day or roughly 15 to 30 cubic yards per week. Ash disposal is a negotiated price dependent on analysis of the actual material. The ash may be land applied, mixed with compost or lime used as daily cover in a landfill. The worst case cost scenario is $20.22 per cubic yard in a landfill.

In general 2.5 tons of sustainable biomass is available per acre in this region (opinion of biomass expert Anders Evald). Sustainable harvest of biomass on Tribe owned land of approximately 2,400 acres could reach 6,000 tons maximum (with additional biomass plantations) and this would not be adequate to supply the large commercial heating and electric requirements at the Turtle Creek Casino Hotel and the Grand Traverse Resort--that could be as much as 42,000 US tons per year if 100% electric generation and heat is desired from a biomass CHP system. However, with 1.3 million acres in a five county area, between just 1% and 2% of this land area contains the required sustainable biomass growth for meeting 100% of the Tribes heating and electric generation needs. Sustainable biomass resources are abundant within a 50 mile radius of the Tribe.

These biomass fuel supply conclusions are based on three primary references, 1) the review recent biomass studies: Clean Energy from Wood Residues in Michigan, Michigan Department of Labor & Economic Growth, Dulcey Simpkins, June 2006, and Trends in Michigan Forest Product Industry 2000-2004, George H. Berghorn, Michigan Forest Products Council, Nov. 2005, 2) phone discussions and site visits with biomass harvesting and transport firms in the McBain, Michigan area, and expert opinions, especially with international biomass expert Anders Evald of Force Technology who reviewed the biomass resource in Mid-Michigan.

In summary, it is clear there are plentiful renewable wind, solar and biomass resources in the Grand Traverse Band region to supply the energy needs of the Tribe.

Work Task Review

The following section provides a detailed discussion on the work tasks outlined in the grant.

Tribal energy load assessments

Tribal energy loads are covered in the previous energy demand section in this report. See above tables and charts.

Site specific renewable resource monitoring

The Tribe installed a 50 meter (164 ft.) meteorological ("met") tower with wind speed, direction and temperature sensors installed at 30, 40 and 50.5 meters height. The met tower resides on its lands between the Grand Traverse Resort and the Turtle Creek Casino, on an 80 acre parcel called the "Hoxie Property". This property has a high north-south ridge that can accommodate two large commercial wind turbines. There is a utility electric sub-station adjacent to the property.

The met tower was installed with cooperation from the local municipal utility, Traverse City Light and Power (TCL&P). TCL&P was engaged in its own wind resource study and installed a second met tower on the west side of Traverse City. A memorandum of understanding was signed between the GTB and TCL&P to share wind data and the results of the regional wind resource study that was completed in 2007 in conjunction with these two met towers.


Met tower with the Grand Traverse Resort in the background.

Met tower inspections and data gathering were made approximately every two weeks to insure good data recovery. 100% data recovery was accomplished for the one year study. Wind shear and other wind resource analysis was completed based upon this data. Details of this study are provided in the report, "Wind Resource Study of the Grand Traverse Region" July 2007 (see Appendix A).

Based on this study wind power production estimates have been made for various commercial wind turbines. Output projections for various wind sites in the GTB region were made based on a selected large commercial wind turbine.

<u>Transmission and interconnection considerations</u>

For commercial applications, discussions for electrical interconnections have been primarily with TCL&P staff engineers. The Tribal facilities and homes in the region, however, have five electric utilities available for service, two municipal utilities (TCL&P and Charlevoix Municipal Electric Department), two rural electric cooperatives (Cherryland Electric Cooperative and Great Lakes Energy Cooperative) and one investor owned utility (IOU), Consumers Energy. The majority of GTB electric supply comes from Consumers Energy at the Grand Traverse Resort and Peshawbestown commercial and government facilities, including the Leelanau Sands Casino and the Strong Heart Center. Cherryland Electric Cooperative serves the Turtle Creek Casino Hotel and many rural residential districts. Great Lakes Energy Cooperative serves the rural areas near Charlevoix and on Beaver Island. TCL&P serves GTB facilities in Traverse City, many GTB Traverse City and Garfield Township residents and has, or will have, franchises in adjacent townships where there are GTB commercial facilities.

There are advantages and disadvantages having many electric distribution utilities. One advantage is that there can be a competitive atmosphere between the various electric utilities thus providing the opportunity for GTBto select the best electric utility option, at its larger primary service facilities,. In addition, Michigan's 21st Century Energy Plan will also play a role in the selection process. . In 2007, the Michigan Public Service Commission (MPSC) released Michigan's 21st Century Energy Plan that details a statute requiring all utilities to have a Renewable Energy Portfolio Standard that by 2015, 10 percent of their energy sales must come from renewable energy. As a result of this statute the Tribe will find that not only will they be able to plan to meet their own energy needs through renewable energy but increase the feasibility of selling any excess energy.

The primary service facilities include the Grand Traverse Resort, the Turtle Creek Casino Hotel, the Leelanau Sands Casino and all adjacent governmental and public facilities in Peshawbestown. A few years ago over thirty metered facilities in Peshawbestown were connected under a single "primary service" meter and all transformers and power lines inside the primary meter are owned by GTB. Both the Grand Traverse Resort and Turtle Creek individually have primary electric service with GTB owned transformers.

Most of the large commercial wind and biomass CHP plants are proposed to be adjacent to the Grand Traverse Resort and Turtle Creek facilities, where the largest electric loads occur. In the Grand Traverse Resort and Turtle Creek neighborhood there are two substations, one owned by Consumers Energy (the

IOU) and one by the rural electric generation and transmission cooperative, Wolverine Power Supply Cooperative, that serves Cherryland Electric Cooperative.

In addition, TCL&P may consider a sub-transmission power line, should it collaborate with GTB on new wind or biomass facilities. TCL&P is in need of new electric power generation and is considering various options, including a biomass CHP plant.

The two existing utility sub-stations have a total of 12.5 MW electric capacity and therefore, depending upon the final size and scope of possible wind and biomass CHP plants, it is likely there will be required retrofit and expansion of these sub-stations. One of these sub-stations is owned by the cooperative and one by the IOU, Consumers Energy. Depending upon further analysis and specific plant sizes, a new substation may be considered. Preliminary discussions have been held with utility engineers, however, no detailed engineering or interconnections can be undertaken before specific wind and biomass CHP plants are identified.

Net metering: New expanded net metering regulations For small renewable electric power systems, 150 kilowatts (kW) and under, are in place for Michigan. This capacity was just increased from 30 kW to 150 kW with the MPSC 2007 legislation. Net metering into the grid allows for a retail energy price one-to-one offsets, up to the monthly billed consumption level. Electricity generated in excess of consumption is paid at a lower “avoided cost market” rate. These utility retail energy prices paid (offset) for small scale renewable energy systems increase the benefits to residential and small commercial renewable energy generation, but they do not come close to making small wind power and solar electric systems economically viable. Additional incentives are required to boost the implementation of small renewable energy systems for the Tribe. Economic analysis, shown below, will illustrate the cost differences between new small scale distributed wind and solar electric systems and utility grid retail prices.

<u>Technology analysis</u>

Technology review and analysis was made on the four renewable energy technologies and systems that have proven reliability. These are:

- Wind power (electricity)
- Biomass (heat and electric power)
- Solar thermal (distributed hot water)
- Solar photovoltaics (electric)

The following graph (Figure 9) illustrates the cost curves for these technologies in the GTB region. More details will be provided in the economics discussion below.

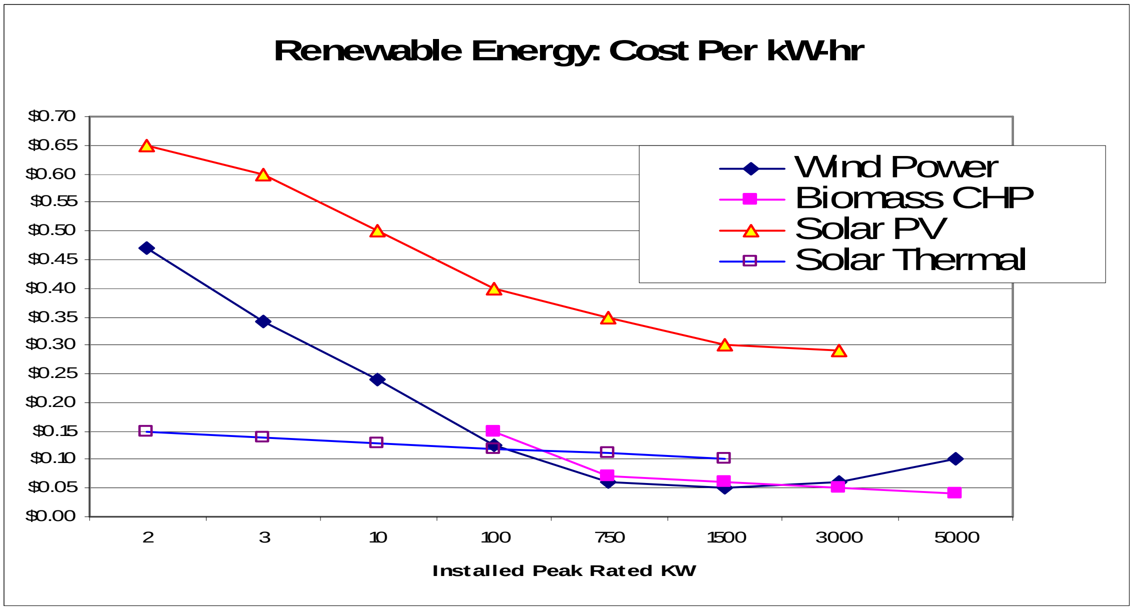

Figure 9. Renewable Energy: Cost Per kW-hr

Wind power systems, both small and large scale were assessed for applicability in the GTB region.

Large scale wind power: The mid-size and large scale wind turbine market, from 100 kW to 3,000 kW peak ratings, with rotor diameters of 21 meters (68 ft) to 100 meters (328 ft), in the USA has been in flux in recent years. Wind turbine supply in these size ranges can be found; however, choices and sources have been very limited. Prior to the national and international financial crisis this fall of 2008, due to large demand and short supply, the most well known large wind turbine manufactures would not supply small wind turbine buyers considering one to ten windmills. These suppliers include companies such as Vestas (the largest wind turbine manufacturer in the world), Siemens, General Electric and Gamesa. All of these companies have been focused entirely on large wind farm developments. Teleconferences were held with many of these vendors regarding pricing. Review of recent wind projects installed in the upper mid-west provided additional budgetary cost information.

The turnkey installed cost for these wind turbines ranges from the higher $4,000 per kW for the 100 kW units down to $1,800 per kW for the larger megawatt size (1,000 kW) wind turbines. The pricing for these wind turbines may come down in 2009 -2010 with recent lower material costs (copper and steel, for example), increased production, and delays in large capital wind farm developments due to the 2008-09 financial crisis.

Due to the moderate wind regime found in the Grand Traverse region, Class 2 – 3 USA, and Class III Euro standard, in order to generate cost competitive wind power, larger scale wind turbines, 750 kW plus, optimized for moderate winds, on relatively tall towers (70 to 100 meters) are required. A wind power cost curve shown below in the economics discussion is illustrated. Smaller, mid-size wind turbines may be considered; however, additional incentives, valuing environmental and social benefits and the long-term fixed pricing (from wind power) advantage must be included to provide the motivation for these installations.

Specific large wind turbines considered and analyzed for the GTB wind sites included the Vestas V90-2.0 and the Gamesa G58-850, installed on 80 meter (260 ft) towers. These two wind turbines are representative of moderate wind regime, Euro Class III, windmills that can provide the most cost competitive energy. The 100 kW class wind turbines, especially the Northwind 100, were also analyzed and cost details are provided in the economic section below.

Small scale wind power: Small wind turbines, from the 2 kW up to 100 kW sizes were analyzed for consideration at GTB homes and facilities. Windmills examined included the Southwest wind power models; the Skystream 3.7 (1.8 kW), the Whisper 500 (3 kW), the Bergey Excel (7.5 - 10 kW), and the Ventera VT10 (10 kW). These small windmills provide electricity at a cost from 45 cents per kWhr down to 15 cents per kW-hour for the larger small machines, depending on the specific site. Recently approved federal tax credits for small windmills may be available for Tribal members paying federal taxes.

<u>Solar Thermal Systems</u>

Solar hot water heating can be cost effective especially in comparison to those homes and facilities that are using either electricity or LP gas for hot water heating. An energy price comparison table is provided in the economic section below. The common flat plate solar collector, such as that made by Thermo-Dynamics is representative of the tested and reliable technology available. These systems can be sized for an individual home or for larger commercial applications. Analysis has been completed for the installation of 400 dispersed residential and commercial systems in the GTB region as an example of the potential.

Presently, there are significant tax credits (30%) available for residential and commercial installations for Tribal members and facilities that pay US federal taxes.

Solar hot air heaters, in contrast to hot water heaters, were not considered due to the fact that a large portion of solar resources occur during the summer non-heating season in the GTB region. Domestic hot water heating is required during all seasons and hot water provides the basis for needed solar energy storage during night time and cloudy periods.

Solar concentrating parabolic thermal systems were not examined in detail due to the limited winter heating season solar resources and the higher cost of these systems. Presently these systems are not considered as a priority. but may be considered in the future. The GTB region climate is characterized by “lake effect” meaning cloudy winters due to the westerly winds coming across Lake Michigan. The solar resources , from the spring to fall, are as good as most regions in the USA.

Solar photovoltaic electric systems:

Solar electric system technologies were examined for application in the GTB region. Solar photovoltaic (PV) systems provide the highest reliability and long-term durability of any electric generation source, with low operating costs. This is evidenced by our complete reliance on solar electric systems in space and in remote locations for all of our modern communication systems.

Due to the yet high capital cost of solar electric energy (see cost charts and graphs) and lack of incentives, its role as a significant renewable energy generation source for GTB is limited to remote locations, stand-by emergency systems and early stage demonstration projects. Any investment in solar electric systems, however, is an investment in long-term energy security and environmental benefits. With proper incentive programs and fair cost accounting to include environmental and social costs, solar PV may become a significant energy source, as seen in Germany under their “feed-in-tariff” program. Under this innovative policy Germany has captured fifty percent of the worlds’ solar PV market, in a county with the same or lower solar resources as the GTB region.

GTB can and should install solar electric systems, within its budget constraints, in strategic applications to gain experience and to make a long-term investment in this fixed price electric source. Both crystalline and amorphous solar PV technologies are well proven and are supplied with 20 year or more warrantees. Solar electric systems can be installed in various configurations:

- Grid intertied with DC/AC inverters without battery storage (with net metering).
- Grid intertied with DC/AC inverters with battery storage (net metering or not)
- Grid independent systems with DC/AC inverters and battery storage
- Grid independent systems with DC only and battery storage (navigation lights, etc.)

Grid intertied solar electric is the most common and cost effective approach world-wide since the added costs of battery storage and controls are avoided. For remote locations, battery storage and controls are required. A DC/AC inverter is required if alternating current (i.e. AC 120 v) is necessary.

These solar electric systems can and have been installed in wide ranging electric capacities, from a 50 watts to over 1,000 kilowatts (1 mega-watt).

Biomass heat and electricity systems

As discussed in the summary above, woody biomass provides the most cost effective and widely available combustion fuel that can be sustainably harvested in the GTB region. Biomass however, can be utilized poorly and inefficiently with negative environmental consequences or efficiently, sustainably and environmentally beneficial, depending on selection of technologies and applications.

Cord wood is cost competitive for use in small home and small commercial applications; however, the wood stoves and wood boilers should have the cleanest available combustion systems such as EPA approved catalytic converters, high temperature efficient combustion, with systems sited where smoke and particulate emissions can be controlled to minimize impacts. Such systems are most appropriate in the rural areas of the GTB region. Many wood species are available for utilization and most importantly when they are properly air dried and seasoned. Maple tree species are the most favored for biomass but there are many fast growing species that are sustainably harvested. Some of these include varieties of pines, poplar, ash and birch—harvested on a sustainable basis.

Other small scale biomass options include pellets, pressed fiber logs, and dried cherries, assuming the cherries are dried with minimum use of fossil fuels. The cost of these biomass fuel range more closely to natural gas, and are competitive with electric and LP gas heat. Pellet stoves provide cleaner and more efficient combustion with forced combustion air, in contrast to the conventional wood stove. They produce less smoke and odor than conventional wood stoves. They do, however, require electricity to power the combustion air fan for efficient operation. Wood pellet fuel can be supplied in 40 pound bags or in small truck loads dumped or shoveled into dry storage containers with automated hopper feed systems. Semi-automated operation pellet stoves and boilers can be installed for residential, commercial, public and small district heating systems in the GTB region; however, at a larger scale the low cost and high availability of wood chips provides a more cost effective biomass option.

A wood pellet production and distribution business could be developed under the guidance of the Tribe, assuming a large number of pellet stoves are to be installed.

For larger commercial biomass heating and electric generation woody biomass in the GTB region is best applied in the form of wood chips. Many sizes and types of commercial wood chip boiler systems are available for consideration. Heat only systems used for small commercial or school size facilities range in size as small as 500,000 BTU/hr capacity (150kWt). Examples of these include units that range from small wood boilers with multi-fuel options such as HS Tarn, and larger units to fifty million BTU/hr, such as the Chiptec models and the larger grate fired boilers such as Wellons.

The larger commercial wood chip boilers all require good emission control systems including ash and particulate cyclones, bag filters and precipitators. Other components include wood delivery, storage and handling systems, ash handling systems, water treatment, and flue gas condensation for improved efficiency. The following diagram, (Figure10) illustrates the components of a high quality commercial wood chip boiler system. From right to left, grapple crane automated fuel feeding from the storage bin, wood boiler, bottom ash removal, a cyclone to remove large particulates and ash, filter or precipitator to remove fine particulates, flue gas condensation to recover exhaust gas heat and improve efficiency and the exhaust chimney.

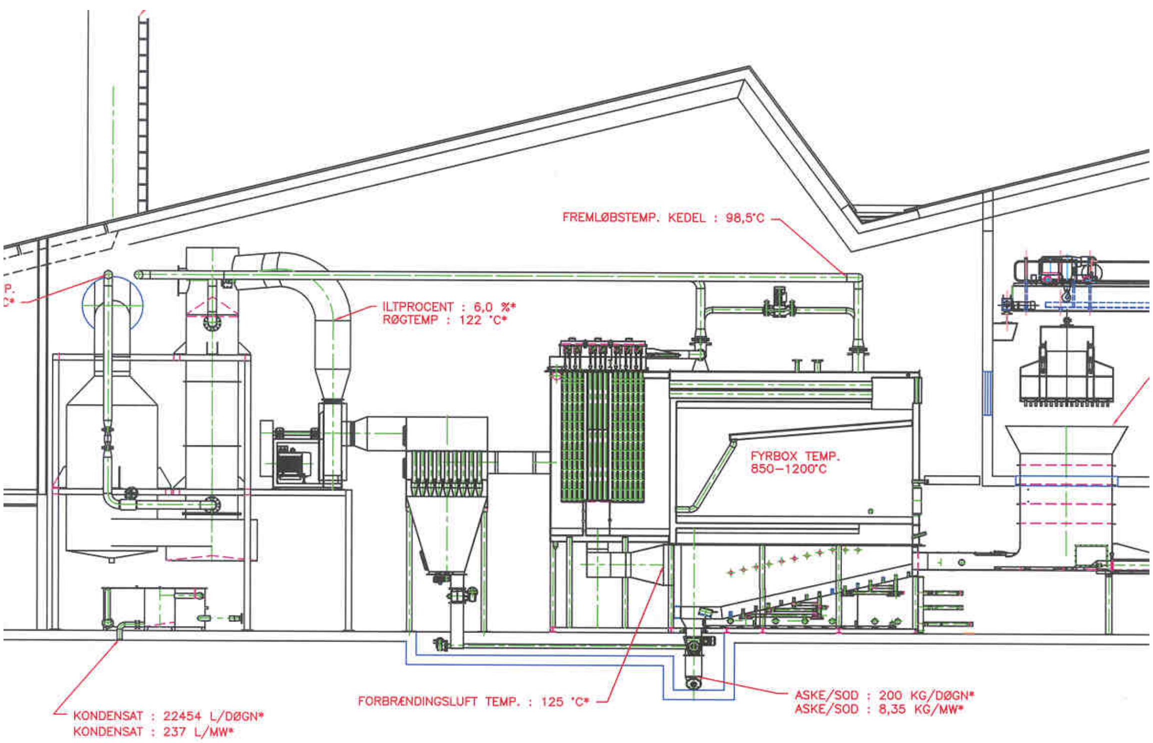

Figure 10. Commercial Wood Chip Boiler

Heating with hot water, distributed at 180 F to 200 F degrees, is the most efficient and cost effective commercial heating system. Steam heating systems are outdated and inefficient for such applications. Steam boilers however, are used when a combined heat and power (CHP) system is utilized to make both heat and electricity. After electric production from the steam turbine, the steam is condensed and with heat exchangers the heat is provided for hot water heating.

For heating only, commercial wood boilers will have 80% or greater efficiency. Such a system is proposed for the higher density residential areas in Peshawbestown. This includes a district heat piping system to deliver hot water to each home and apartment. A heat exchanger is installed at each residence to transfer the heat to the force air furnace, hot water boiler and domestic hot water heater. Heat delivery is metered just as with a gas or electric meter.

A larger biomass CHP plant is proposed for the Turtle Creek Casino Hotel and Grand Traverse Resort area, sized to provide up to 100% of the electric and thermal heating needs of the two facilities. A summary of this analysis is supplied below. To meet the electrical and heating needs for these two Tribal commercial facilities a CHP plant size of 5 MWe (electrical) is adequate for the current needs. More details are provided below in the economic section.

CHP biomass plants can run at +/- 80% efficiency resulting from capturing steam for heat as opposed to venting excess energy to the atmosphere in contrast to biomass fired steam turbine electric generation only which operate at +/- 30% efficiency, such as in biomass plants in Cadillac, Grayling and McBain, Michigan. Wasting the excess heat (up to 60% waste) results in more expensive electricity than a CHP system and this is an inefficient use of the biomass resource. When generating electricity it is very important to utilize biomass CHP as a public venture, distributing both hot water and electricity, distributing hot water typically done with cold water and sewer infrastructure.

Estimated capital cost for such a system will, depending on final design, range from $15 - $25 Million. A smaller plant that just serves the needs of the Tribe will be on the lower end of the costs and one that provides excess electricity for other consumers will be on the higher side.

The electric cost per kWhr for this larger biomass CHP plant proposed for GTB will range from $.04 to $.08 per kWhr, depending upon the scope of district heat sales, the nature and quantity of heat sales and heat pipe interconnection costs. For example, one biomass CHP project being planned for a public university in Central Michigan is projecting an electric energy cost of $.035 to $.04 per kW-hr (based on a private interview with the plant manager) with a steam turbine capacity of 15 MWe and, importantly, with an existing district heat distribution system.

If for example, the biomass plant is sized optimally for the electric and heating loads for the Tribal facilities the lower cost electric price can be achieved with heating cost, lower than natural gas. More details are provided in the economic section below.

District heating piping system was reviewed by the consulting Tribal Civil Engineer. Preliminary biomass district heating engineering and cost analysis has been completed on Peshawbestown and the Grand Traverse Resort / Turtle Creek Casino Hotel.

Economic Analysis

The following graph illustrates the cost curves for the technologies under study in the GTB region.

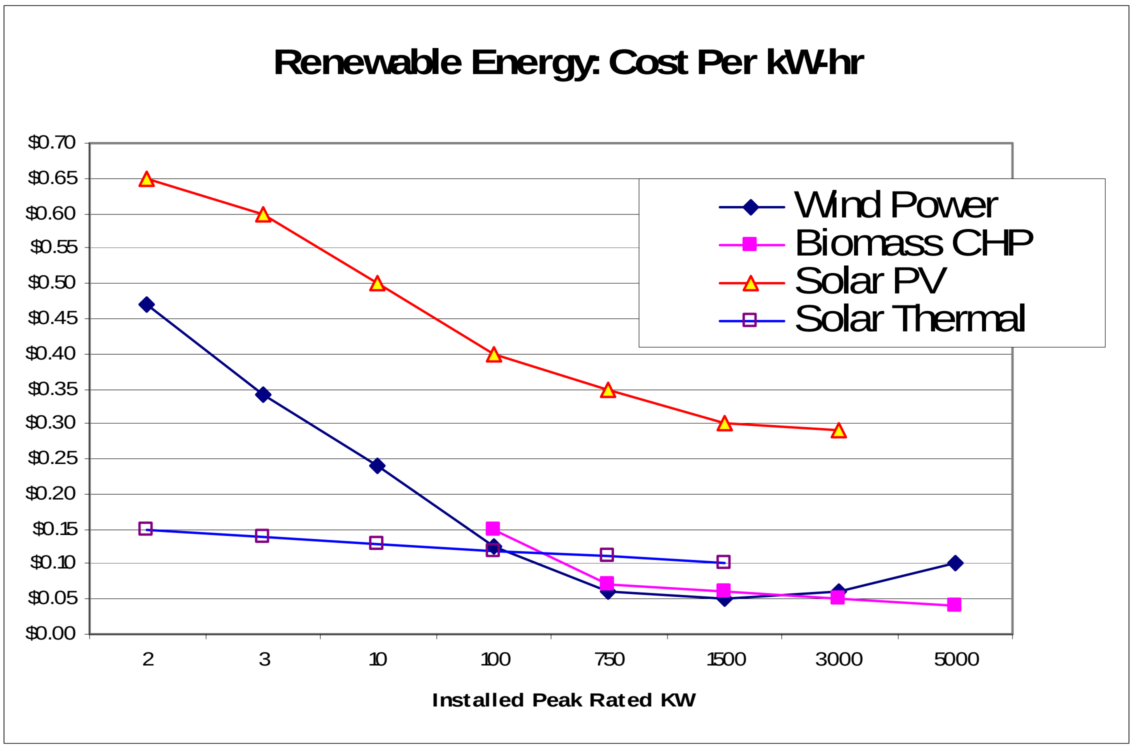

Figure 11. Renewable Energy: Cost Per kW-hr

Economic analysis has been conducted and completed on biomass combined heat & power (CHP), solar thermal, solar PV and wind power applications for Peshawbestown, the GT Resort / Turtle Creek Casino and residential complexes in the total Tribal region.

As shown in the energy cost table below (Table 2) large commercial wind power and biomass CHP provide the most economical renewable energy options for the Tribe. Energy efficiency is also, as always, a priority. Cord wood, wood pellets, solar thermal, small wind power and solar electric costs follow in cost respectively.

Energy Cost Comparison 2008 Ranked By Lowest to Highest	Unit	Unit Cost	Energy Only Cost / kWh	All Costs / kW-hr	W / Enviro Costs/kWh	Cost per MMBTU
Efficiency /Passive Solar	kW-hr	$ -	$ -	$ 0.03	$ 0.03	$ 8.79
Wood Chips	US Ton	$ 26.00	$ 0.007	$ 0.03	$ 0.04	$ 10.25
Large Wind	kW-hr	$ -	$ -	$ 0.06	$ 0.06	$ 17.58
Cord Wood	Face Cord	$ 70.00	$ 0.065	$ 0.06	$ 0.07	$ 19.04
Dryed Cherry Pits or Pellets	Ton	$ 200.00	$ 0.067	$ 0.08	$ 0.08	$ 23.44
Natural Gas CHP (electric)	CCF	$ 1.20	$ 0.055	$ 0.07	$ 0.09	$ 26.37
Natural Gas CHP (heat)	CCF	$ 1.20	$ 0.055	$ 0.07	$ 0.09	$ 26.37
Natural Gas Large	CCF	$ 1.20	$ 0.055	$ 0.08	$ 0.10	$ 29.30
Natural Gas Res /Comm	CCF	$ 1.25	$ 0.057	$ 0.09	$ 0.11	$ 32.23
Lg Commercial Grid Electricity	kW-hr	$ 0.070	$ 0.070	$ 0.09	$ 0.13	$ 38.09
Solar Hot Water	kW-hr	$ -	$ -	$ 0.15	$ 0.15	$ 43.95
Sm Commercial Electricity	kW-hr	$ 0.100	$ 0.100	$ 0.11	$ 0.15	$ 43.95
Residential Electricity	kW-hr	$ 0.100	$ 0.100	$ 0.11	$ 0.15	$ 43.95
LP Gas	Gallons	$ 2.50	$ 0.121	$ 0.14	$ 0.18	$ 52.74
New Coal Fired Electricity	kW-hr	$ 0.170	$ 0.170	$ 0.17	$ 0.19	$ 55.67
Gasoline	Gallons	$ 3.90	$ 0.160	$ 0.18	$ 0.22	$ 64.46
Heating Oil	Gallons	$ 4.85	$ 0.162	$ 0.18	$ 0.23	$ 67.39
New Atomic Electricity	kW-hr	$ 0.23	$ 0.230	$ 0.23	$ 0.25	$ 73.25
Small Wind	kW-hr	$ -	$ -	$ 0.28	$ 0.28	$ 82.04
Solar PV Electric	kW-hr	$ -	$ -	$ 0.60	$ 0.60	$ 175.80

Table 2. Energy Cost Comparison

The following chart illustrates the total Tribal region energy costs from Charlevoix to the north, Antrim, Grand Traverse, Peshawbestown and Benzie.

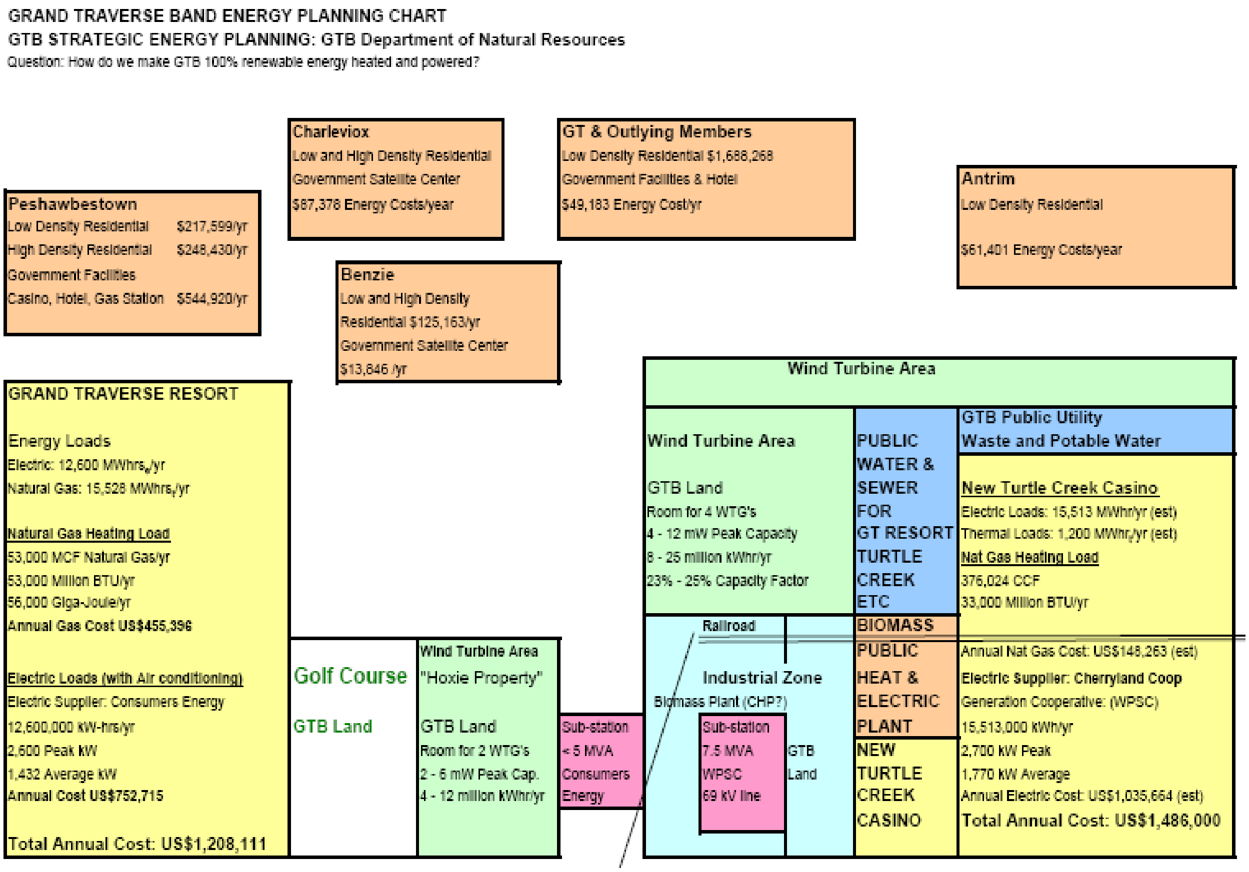

Figure 12. Grand Traverse Band Energy Planning Chart

Large wind power economics

The following excerpts from the “Wind Resource Study of the Grand Traverse Region” July 2007 illustrate the energy output expected from a large wind turbine on an 80 meter (260 ft.) hub height tower located in the Turtle Creek area.

6.3.3 Annual Energy Productions at Turtle Creek and Long Lake

The annual energy productions are calculated for 4 wind turbines located at Turtle Creek and 2 wind turbines located at the open area 500 m east of the Long Lake mast. The Turtle Creek site is located approximately 1.8 km east of the GT Resort mast with no major disturbances of the wind flow in between , and therefore it is assessed that the wind measured at the GT Resort mast represents the wind conditions at Turtle Creek.

No micro-siting has been carried out in order to optimise the energy output, as the specific site restrictions are unknown at present. However, the turbines are positioned in a north-south orientated row in order to minimise the wake loss and with a mutual distance corresponding to 5 rotor diameters.

The expected level of annual park production (AEP_{Park}), including wake loss, is calculated using WAsP, based on the GT Resort and Long Lake long-term corrected wind distributions, the power curves and C_T curves for the chosen wind turbines and the digitised map.

	AEP_{Park}	Capacity Factor[4]
Turtle Creek, 4 Vestas V90 2.0 MW	17.38 GWh	24.8 %
Turtle Creek, 4 Gamesa G58 850 kW	6.89 GWh	23.1 %
Long Lake, 2 Vestas V90 2.0 MW	9.19 GWh	26.2 %
Long Lake, 2 Gamesa G58 850 kW	3.48 GWh	23.4 %

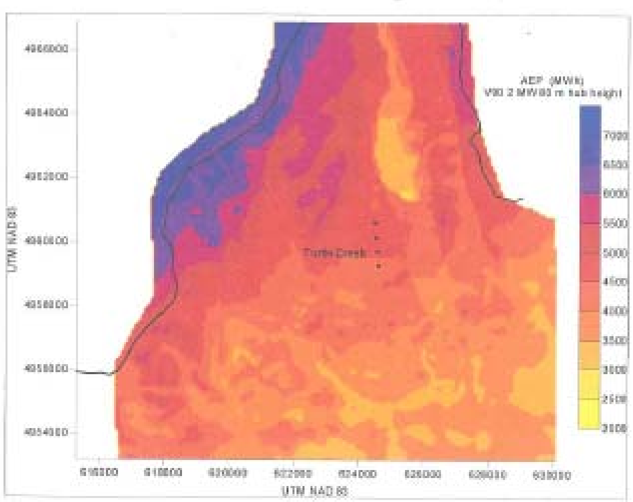

Figure 40 Annual energy output (MWh) from a Vestas V90 2.0 MW wind turbine at GT Resort

The following pro-forma spreadsheet illustrates the economics for a single large scale wind turbine at the Turtle Creek wind sites. With the following assumptions as shown above for a single wind turbine:

- $3.8 million turnkey installed cost
- $1,900 per kW installed
- 6% financing interest rate for 20 years
- 10% down payment, 90% debt
- 2 cent per kW-hr, 10 yr, Renewable Energy Production Incentive (REPI)

GTB Turtle Creek			PRO FORMA CASH FLOW PROJECTIONS			Dec '08	
WIND TURBINE GENERATOR'S		1	90		Wind Turbine	2000	kW
		2000 kW			Net Wind Output	730	kWhrs/yr/m2
					Rotor Dia	90	meter
ASSUMPTIONS				Cost/kW			
Total Cost:			$3,800,000	$1,900	Finance Term:	20	years
Debt:	90%		$3,420,000		Interest Rate:	6.00%	year
Equity:	10%		$380,000		Federal State Tax:	0%	per annum
Wind Power Purchase Electric Rate or Offset:			$0.0700		Federal Incentive (10 yrs):	$0.0190	per kW-hr
Electric escalation rate:			2.00%		Federal Tax Credit:	$0.000	
Annual Output kwh/yr./WTG:			4,643,183		O&M & REPI Escalation rate:	2.00%	
Maintenance fee/yr./WTG:			24,000		Mgt. fee/yr./WTG:	$2,400	
All-Risk Insurance/$100:			$0.25		Utility/Sub. fee/yr./WTG:	$1,200	
Air Pollution Emission Credits/kW-hr			$0.010		Land Rent/yr./WTG:	$0	
					Local Property Tax:	0.00%	

YEAR	2010	2011	2012	2013	2014	2015	2016	2017
	1	2	3	4	5	6	7	8
Price/kwh	0.0700	0.0714	0.0728	0.0743	0.0758	0.0773	0.0788	0.0804
Output/year	4643183	4643183	4643183	4643183	4643183	4643183	4643183	4643183
Electric Sales Revenues	325023	331523	338154	344917	351815	358851	366028	373349
Fed Re Incentive Pmt./credit	88220	89985	91785	93620	95493	97403	99351	101338
Air Emission Credits	46432	47360	48308	49274	50259	51264	52290	53336
GROSS INCOME	459,675	468,869	478,246	487,811	497,567	507,518	517,669	528,022
EXPENSES								
Land Rent	0	0	0	0	0	0	0	0
Management	2,400	2,448	2,497	2,547	2,598	2,650	2,703	2,757
Maintenance	24,000	24,480	24,970	25,469	25,978	26,498	27,028	27,568
Local Property Taxes	0	0	0	0	0	0	0	0
All-risk Insurance	7,125	7,268	7,413	7,561	7,712	7,867	8,024	8,184
Performance Insur.	0	0	0	0	0	0	0	0
Utility & Substation	1,200	1,224	1,248	1,273	1,299	1,325	1,351	1,378
TOTAL EXPENSES	34,725	35,420	36,128	36,850	37,587	38,339	39,106	39,888
NET REVENUE	424,950	433,449	442,118	450,960	459,980	469,179	478,563	488,134
Debt Service	298,171	298,171	298,171	298,171	298,171	298,171	298,171	298,171
Total Debt & O&M Expense	332,896	333,591	334,299	335,022	335,759	336,510	337,277	338,059
CASH FLOW	126,779	135,278	143,947	152,789	161,809	171,008	180,392	189,963
Debt Coverage Ratio	1.43	1.45	1.48	1.51	1.54	1.57	1.60	1.64
Cost/ kW-hr. (pre REPI)	$0.072	$0.072	$0.072	$0.072	$0.072	$0.072	$0.073	$0.073
Cost/kW-hr With REPI (public)	$0.053	$0.052	$0.052	$0.052	$0.052	$0.051	$0.051	$0.051
Principal	92,971	98,549	104,462	110,730	117,374	124,416	131,881	139,794
Interest	205,200	199,622	193,709	187,441	180,797	173,755	166,290	158,377

FINANCIAL SUMMARY DATA			
BENEFIT/COST RATIO	1.59		
PV of Benefits w/REPI	$8,859,711		Net Present Value (25 yr)
PV of Costs	$5,567,613		$3,292,098
First year "Cash on Cash"	11.18%	(net revenue/total cost)	
25 YR PRE TAX IRR	38.42%		
25 YrR AFTER TAX IRR	#NUM!		
NPV Electric Cost/kwh	$0.045		
Discount Rate	3.00%		

Table 3. ProForma Cash Flow Projections

The financial results in Table 3 above show a 5.3 cent per kW-hr cost with REPI and a 7.3 cent per kW-hr cost without the REPI incentive payment. “levelized” cost of power is 4.5 cents per kilowatt hour. The net present value benefit / cost ratio is 1.6 with a 25 year net present value (NPV) of $3.2 million dollars. This NPV is actual cash accruals to the Tribe after paying all the costs and generating a significant amount of electricity for the Tribe.

Changing the results of this analysis plus or minus 15% still provides the basis for an economically viable investment without consideration of the environmental benefits and long term energy price security. Ten very large wind turbine installations will generate over 100% of the Tribes electric consumption of 42 million kW-hrs, on a net annual basis.

Biomass heat and electric power generation

Two biomass economic feasibility studies are included to show the complete range of biomass plant heating and electric generation possibilities in combination with district heating. On the small commercial scale a biomass heating only boiler connected to a residential district heat system illustrates the most expensive per metered consumer, implementation of this technology. A system designed for the west Peshawbestown residential area was chosen for this study. On the larger scale, where the highest heating and electric loads exist, a system was analyzed for the Turtle Creek and Grand Traverse Resort area. All other potential biomass district heating and electric systems appropriate for other Tribal facilities and residential districts fall economically between these two examples.

For the West Peshawbestown district, with a total installed cost estimated at $1.7 million, this biomass district heating system can provide heat to the entire area, up to 120 homes at the same cost, or less than existing natural gas costs. Under these projections annual fuel cost savings exceed $100,000. In addition to these cost savings, each home will be able to shut down the existing space and hot water heating system using retrofitted heat exchangers that will provide both space heat and domestic hot water heat. A simple closed loop heat exchanger, (the size of a two drawer file cabinet) is utilized for transferring the district heat to both space heating and domestic hot water heating units. Air handling units with heat exchangers will be installed for buildings that utilize forced air heating furnaces. Heat delivered to each home or apartment is measured with a heat meter that calculates the hot water flow rate and temperature difference between the incoming hot water and colder water return. The energy consumption is metered just as with a gas meter.

The estimated cost per home for this installation is approximately $15,000. This is typical of costs seen in Denmark for neighborhood district heating systems. There is very limited experience in the USA for such systems.

Operation and maintenance costs are not included in the following table; however, the operation and maintenance of the 120 existing individual heating systems will far exceed the operation and maintenance of this system. The following table highlights the cost of installation and operation for heating the West Peshawbestown residential area. The operation and maintenance staff will required will be no more than two persons, trained technicians, on a full or part-time basis. An automatic service call-up system is suggested in the event of an operation failure, and a technician must be available within a short time period. A hot water storage system is provided to balance the heating loads. A wood chip storage system, able to store five to seven days of fuel will be required. Such a container, either steel or concrete, covered from weather, will be similar in size to four semi-truck trailers. Automatically controlled augers will feed fuel to the wood boiler. The following figure 10 illustrates an example of an automated wood chip fuel handling and biomass boiler suitable for this application. A small pole building, approximately 40 ft. by 60 ft. will accommodate this system.

The hot water boiler proposed and analyzed for this system in West Peshawbestown was sized by a professional heating plant engineer from Ellis Energy of Zanesville, Ohio, according to the design heating loads established during a site visit, and from energy and climate data. Back up heating capacity, should the system require shut down for maintenance, will be provided by auxiliary heating systems that will remain in place in the larger facilities. Annual maintenance costs are minor and will be substantially lower than existing maintenance costs for the existing systems that will be shut down and or mothballed. Ash removal, at this scale of use, will be available for pick-up by gardeners and farmers for use in agriculture.

Peshawbestown District Heating Loop

COST ESTIMATE

	BUDGET
HURST HOT WATER BOILER, 600 GPM ~ 130F IN TO 180 F OUT	$411,825
FREIGHT TO JOBSITE	$25,000
FOUNDATION	$9,000
FIELD ERECTION	$125,000
START-UP & OPERATOR TRAINING	$9,500
FUEL HANDLING	$95,904
OPTIONAL EQUIPMENT	$62,909
TOTAL BOILER COST, INSTALLED AND RUNNING	**$739,138 BUDGET**

$525.00	AIR HANDLING UNIT COST	
$200.00	AIR HANDLING UNIT INSTALLATION---GUESS ONLY	
$725.00	TOTAL COST PER INSTALLED AIR HANDLING UNIT	
120.00	AIR HANDLERS REQUIRED	
$87,000	**TOTAL AIR HANDLING UNITS COST**	**BUDGET**

PIPING COST

$650,000	**NEED SITE SPECIFIC DETAILS ON INSTALLATION.**	**BUDGET**

ENGINEERING AND PROJECT MANAGEMENT

$200,000	**BUDGET**

TOTAL INSTALLED COST

$1,676,138	**BUDGET**

WOOD FUEL COST

4500	BTU/LB WOOD HEAT CONTENT
4350	POUNDS PER HOUR OF WOOD REQUIRED
2.175	TONS PER HOUR OF WOOD CHIPPED AND DELIVERED
$22.00	DOLLARS PER TON FUEL COST
$47.85	FUEL COST PER HOUR FOR 120 HOMES
$0.244	PER THERM WOOD FUEL COST

NATURAL GAS FUEL COST	
80,000	BTUH PER HOUSEHOLD
0.8	THERMS PER HOUSEHOLD
$1.00	PER THERM NATURAL GAS COST
100	HOMES
80.00%	NATURAL GAS FURNACE EFFICIENCY
$100.00	FUEL COST PER HOUR FOR 120 HOMES
FUEL COST SAVINGS	
$52.15	PER HOUR FUEL COST SAVINGS WITH WOOD FUEL
47.9%	WOOD FUEL COST COMPARED TO NATURAL GAS
$250.00	PER MONTH PER HOUSEHOLD NATURAL GAS COST
$119.63	PER MONTH PER HOUSEHOLD WOOD COST COST
$130.38	PER MONTH PER HOUSEHOLD SAVINGS PER HOUSEHOLD BY USING WOOD
120	HOUSEHOLDS
$15,645.00	SAVINGS PER MONTH FOR 120 HOMES IN PESHAWBESTOWN HEAT LOOP
7	MONTHS ASSUMED HEATING PER YEAR
$109,515.00	ANNUAL FUEL SAVINGS IN PESHAWBESTOWN DISTRICT HEAT LOOP
	IGNORES OPERATORS
	IGNORES MAINTENANCE
	IGNORES ELECTRICAL LOAD
SIMPLE PAYBACK	
15.3 YEARS	

Table 4. Peshawbestown District Heating Loop

The larger scale biomass combined heat and power system analyzed for the Turtle Creek and Grand Traverse Resort area is presented with two options, one for self supply for the Tribal facilities and one scaled up to generate additional electricity for distribution to the local electric system to provide additional revenues.

For self-supply, fuel consumption for an initial large biomass plant for the Turtle Creek and Grand Traverse Resort is projected at 42,000 tons per year. Based on 5 days per week this will require on average 4 - 6 trucks per day, each truck averaging 33 tons of biomass.

For the Tribal commercial self-supply option the energy and financial aspects are presented below. This project has a total installed cost of $15.7 million, including an estimated $4 million for the district heat pipe connection between the biomass CHP plant, Turtle Creek and the Grand Traverse Resort. The cost of the district heat pipe between Turtle Creek and the Grand Traverse Resort was estimated based upon specific pricing established for a similar piping system in nearby Traverse City. Hot water will be piped to these facilities with a two-pipe system, hot out and cold return. This system has been sized to meet approximately 100% of the electric demands of the two facilities. With this plant sizing approach, excess thermal energy (heat) is available for other consumers. If this excess heat can be sold the economic benefits are significantly improved.

Operation and maintenance costs are based upon a staff of 2.5 full-time persons with assistance from existing engineering and operations staff at Turtle Creek and the Grand Traverse Resort. The existing heating plants at these resorts will be shut down, freeing up maintenance staff and reducing expenses. The existing heating plants will remain in place for back-up and supplemental heating during maintenance periods.

The present heat and electric costs for these two facilities is $3 million per year and the total debt and operations costs for this biomass CHP plant is estimated to be $2.3 million, providing an annual savings of $700,000. Excess heat available for sale is valued at roughly $1.5 million, with an energy priced to encourage interconnection by other consumers (for example, at 75% of present natural gas costs). There is a great incentive to seek out and interconnect to additional heat loads in the neighborhood. Some of these heat loads could include the industrial buildings to the west of Turtle Creek, new commercial facilities, and other homes and building surrounding the Grand Traverse Resort. With the excess heat sales the cost of electricity is under 3 cents per kilowatt-hour. Without the excess heat sales the cost of electricity is 6.5 cents per kilowatt-hour.

The following Table 5 illustrates this scenario with the benefits of excess heat sales included. In concept, the offer of lower priced thermal energy provides the financial incentive for consumers to pay the cost of the district heat hook up.

GTB RESORT & SPA & TURTLE CREEK 3500 KW CHP			
Wood Fired Steam CHP		50 MMBTU Peak	
	3.625	14.5	MWthermal
Peak Wood Heat Output (million BTU)		50	mmbtu
Wood Fuel Cost per ton	$	22.00	/US ton
Peak Electric Capacity (kW)		3,500	kW
Electric CHP Operating Capacity Factor %		85%	CF
Utility Electric Sale Price $/kW-hr	$	0.050	/kW-hr
Local Electric Sale Price (to self) $/kWh	$	0.060	/kW-hr
Thermal Heating Capacity Factor %	NA		CF
Thermal Heating Sales Price $/mmBTU	$	5.00	mmbtu

CAPITAL COSTS	
Wood Fired Unit at Site w/ Boiler & storage	$8,000,000
Mechanical District Interconnection	$4,000,000
Steam Turbine	$2,000,000
Building Retrofit & Prep	$1,000,000
Utility Interconnection w/transformer	$500,000
Engineering & Development	$200,000
Legal & Financial Expense	$40,000
TOTAL CAPITAL COST	$15,740,000

COST SUMMARY ANALYSIS			
Installed Capital Cost		$15,740,000	
First Year Fuel, O&M & Admin Cost		$1,207,038	
First Year Capital Recovery Cost		$1,101,800	
First Year Expense (Debt & O&M)		$2,308,838	
Installed Cost per KWe	$	4,497	
Installed Cost per kW-hr/yr	$	0.604	/kW-hr
First Year Cost per kW-hr w/o REPI	$	0.024	/kW-hr
First Yr Cost per kWh w/REPI	$	0.006	/kW-hr

First Year Operating Cost Data			Percent
Fuel	$	914,946	39.6%
Rent	$	-	0.0%
Admin	$	52,122	2.3%
O&M	$	210,458	9.1%
Taxes	$	-	0.0%
Insurance	$	29,513	1.3%
Capital Recovery	$	1,101,800	47.7%
TOTAL	$	2,308,838	100%
Note: Discount Rate for Present Value Calc.		6.0%	

GTB RESORT		50000
New Turtle Creek		33000
		0
Annual Heat Load Requir. (mmbtu)		83,000
Heat Output mmbtu/year		223,380
Heat Cost per mmbtu	$	2.46
Total Heat Fuel Cost/yr	$	548,968
Heat Only $/mmbtu (w/capital & O&M)	$	6.20
Heat Energy $/mmbtu (fuel only)	$	2.46
N. Gas Cost $/mmbtu @75% eff.	$	10.00
Thermal Heat Sales @75%NG Cost	$	1,675,350
Total Electric Expense per/yr	$	633,488
Electric Output kW-hrs/year		26,061,000
First Year Electric Cost per kW-hr	$	0.024
Electricity kWh/yr Available for Sale		(1,939,000)
Value of Excess Elec/yr at $.06/kwh	$	(116,340)
Local Consumption Electric kWh		28,000,000
Percent Local Electric to Total Gen.		107%
Natural Gas Cost/CCF	$	1.00
Energy Cost to Electric kW-hr Price	$	633,488
(assumes thermal energy sold at 75% NG)		
Exess Heat and Electric Sales	$	1,559,010
Energy Efficiency		
Total Wood Fuel Energy in mmbtu/yr		372,300
Heat Output mmbtu/year		223,380
Electric Output kW-hrs/year		26,061,000
Electric Output mmbtu/yr		88,946
Thermal Efficiency		60%
Electric Efficiency		24%
Total Efficiency		
Total O&M & K Cost less Excess Sale	$	749,828
Present Total Cost/yr & T.Ck & GTR	$	3,000,000
Net Annual Savings	$	2,250,172

Table 5. GTB Resort & Spa and Turtle Creek 3500 KW CHP

Recent discussions indicate that there is interest in collaborating on a larger scale biomass CHP plant that can make electricity in excess of GTB needs for transmission to the electric system. An analysis has been conducted for a 10 MW electrical CHP plant as an illustration of the potential economic benefits.

In this first analysis the assumption is that there are no excess thermal (heat) sales beyond the requirements of Turtle Creek and the Grand Traverse Resort. In this scenario the excess electricity, beyond the requirements of the Tribal facilities, amounts to 47 million kW-hrs per year.

With no excess heat sales beyond the use at the two GTB facilities the cost of electricity at the generation bus bar in this scenario is 6.2 cents per kW-hr. As heat sales are increased the additional project revenues drive the cost of electricity to much lower levels.

GTB RESORT & SPA & TURTLE CREEK 10,000 KW CHP			
Wood Fired Steam CHP		150 MMBTU Peak	
	10.875	43.5	MWthermal
Peak Wood Heat Output (million BTU)		150	mmbtu
Wood Fuel Cost per ton	$	22.00	/US ton
Peak Electric Capacity (kW)		10,000	kW
Electric CHP Operating Capacity Factor %		85%	CF
Utility Electric Sale Price $/kW-hr	$	0.050	/kW-hr
Local Electric Sale Price (to self) $/kWh	$	0.060	/kW-hr
Thermal Heating Capacity Factor %	NA		CF
Thermal Heating Sales Price $/mmBTU	$	5.00	mmbtu
CAPITAL COSTS			
Wood Fired Unit at Site w/ Boiler & storage		$16,000,000	
Mechanical District Interconnection		$4,000,000	
Steam Turbine		$4,000,000	
Building Retrofit &/or Prep		$200,000	
Utility Interconnection w/transformer		$600,000	
Engineering & Development		$300,000	
Legal & Financial Expense		$60,000	
TOTAL CAPITAL COST		$25,160,000	
COST SUMMARY ANALYSIS			
Installed Capital Cost		$25,160,000	
First Year Fuel, O&M & Admin Cost		$3,514,384	
First Year Capital Recovery Cost		$1,761,200	
First Year Expense (Debt & O&M)		$5,275,584	
Installed Cost per KWe	$	2,516	
Installed Cost per kW-hr/yr	$	0.338	/kW-hr
First Year Cost per kW-hr w/o REPI	$	0.062	/kW-hr
First Yr Cost per kWh w/REPI	$	0.044	/kW-hr
First Year Operating Cost Data			Percent
Fuel	$	2,744,839	52.0%
Rent	$	-	0.0%
Admin	$	148,920	2.8%
O&M	$	573,450	10.9%
Taxes	$	-	0.0%
Insurance	$	47,175	0.9%
Capital Recovery	$	1,761,200	33.4%
TOTAL	$	5,275,584	100%
Note: Discount Rate for Present Value Calc.		6.0%	

GTB RESORT		50000
New Turtle Creek		33000
		0
Annual Heat Load Requir. (mmbtu)		83,000
Heat Output mmbtu/year		670,140
Heat Cost per mmbtu	$	2.46
Total Heat Fuel Cost/yr	$	1,646,903
Heat Only $/mmbtu (w/capital & O&M)	$	4.72
Heat Energy $/mmbtu (fuel only)	$	2.46
N. Gas Cost $/mmbtu @75% eff.	$	10.00
Thermal Heat Sales @75%NG Cost	$	622,500
Total Electric Expense per/yr	$	4,653,084
Electric Output kW-hrs/year		74,460,000
First Year Electric Cost per kW-hr	$	0.062
Electricity kWh/yr Available for Sale		46,460,000
Value of Excess Elec/yr at $.06/kwh	$	2,787,600
Local Consumption Electric kWh		28,000,000
Percent Local Electric to Total Gen.		38%
Natural Gas Cost/CCF	$	1.00
Energy Cost to Electric kW-hr Price	$	4,653,084
(assumes thermal energy sold at 75% NG)		
Exess Heat and Electric Sales	$	3,410,100
Energy Efficiency		
Total Wood Fuel Energy In mmbtu/yr		1,116,900
Heat Output mmbtu/year		670,140
Electric Output kW-hrs/year		74,460,000
Electric Output mmbtu/yr		254,132
Thermal Efficiency		60%
Electric Efficiency		23%
Total Efficiency		
Total O&M & K Cost less Excess Sale	$	1,865,484
Present Total Cost/yr & T.Ck & GTR	$	3,000,000
Net Annual Savings	$	1,134,516

Table 6. GTB Resort & Spa and Turtle Creek 10,000 KW CHP

While the electric costs of 3 to 6 cents per kilowatt hour may seem low, this cost of electricity is possible for two reasons, 1) the biomass wood chip fuel cost in this market is very low, with $22 per ton, a cost of approximately $0.006 cents per kW-hr (6 tenths of one cent), and fuel costs account for a large portion of the price of the delivered energy, and 2) with heat sales (in addition to electric generation), we achieve high efficiencies in the utilization of the fuel. The CHP efficiency is over 80% whereas a biomass electric steam turbine is roughly 30% efficient. If heat sales are eliminated the cost of electricity can range from 7 to 9 cents per kilowatt hour for a public owned facility. Privately held biomass plants will require higher electric rates to account for higher financing costs, profit margin requirements and higher risk levels.

These biomass CHP plants with district heating are typically optimized economically using large amounts of thermal storage in the form of hot water. This allows fuel consumption to be varied daily, weekly and seasonally with the potential of staging two or more boilers and steam turbines. When for example, electric demand may be low on the weekend heat storage can provide fuel savings. During excess short-term cold periods, heat storage can provide added capacity. In general, the thermal size of a district heating system boiler will not be set at the peak heating load requirement, but at some lower level, with existing auxiliary boilers in the district providing peak period heat.

District heating thermal storage systems typically consist of large silo type tanks with heat exchangers. In a system such as that discussed above the tanks can be 20 feet in diameter and 30 feet tall or larger. The tanks can be attractively designed for aesthetic purpose.

A typical biomass CHP plant in Denmark, such as at Assens, provides electricity and heat to a town population of 5,400. It has added biomass fuel storage and handling, requiring a larger foot print, because it uses four types of biomass.

Energy Efficiency Measures

A survey of proposed general energy efficiency measures is included (see Appendix B GTB Energy Efficiency Review). A detailed comprehensive energy audit of the Tribes facilities is beyond the scope of this report. Past energy analysis has been conducted on many of the Tribal facilities. The buildings, plants and systems are well managed and maintained for efficient operation.

Power market assessment

There are at least seven aspects and opportunities for utilizing or marketing the electric power from GTB renewable energy systems. These include:

- Small scale: net metering
- GTB Self-supply
- Local municipal (TCL&P & MPPA) green power marketing partnership
- Regional rural cooperative green power supply [Wolverine Power (Cherryland), CE, etc.]

- Renewable Energy Production Incentive Payment (REPI) 10 years, with 2 cents/kW-hr
- IOU renewable energy credits,
- Green power markets, carbon credits, green tags, (Native Energy, etc.)

All of these opportunities have been analyzed and considered for providing value to the Tribe.

Michigan has a “net metering” regulation in place for small renewable electric generation that was recently increased from 30 kW to 150 kW’s peak rating. This applies to those electric utilities regulated by the state of Michigan, rural electric cooperatives and investor owned utilities (IOU’s). Over 90% of GTB’s electricity are supplied by these types of utilities.

Due to the low limits on the size of these renewable electric systems this opportunity has limited application for the Tribe. The retail rate for electricity, depending on the electric utility and the rate class (residential, commercial, etc.) ranges from 8 cents to 11 cents per kW-hr. and the amount of electricity that GTB facilities and homes can supply for net metering at the retail rate is limited by monthly consumption (the billing period). Any electricity in excess of consumption is paid a lower avoided cost “market price” which presently is approximately 4 to 5 cents per kilowatt hour depending on the month. Since none of the potential small, 150 kW and under wind and solar electric systems can generate electricity at these prices, (see above cost graph, Figure 11, in the Economic Analysis section) there is little economic incentive to participate in this market. A survey of Michigan consumers who have participated in this program indicates that it is a very small number, less than ten in the entire state.

GTB can generate electricity for its self supply; however, this will require forming its own electric utility and establishing the basis for delivery, metering, billing and servicing its own facilities and contiguous residents. Unless the GTB districts are disconnected from the larger utility grid, special contracts will have to be put in place for the purchase and exchange of electricity--as GTB generated energy is netted out (in an accounting sense). What this means, is that GTB will sell into and purchase from the electric market, and unless the GTB generated electricity is lower cost than the market price, GTB facilities and residences will not economically benefit. GTB could accomplish this, however with the small scale of the Tribe and its distributed and separate loads spread over a six county area, this is not practically reasonable to consider at this time.

Preliminary conceptual discussions and analyses has been conducted with the local municipal electric utility, Traverse City Light & Power (TCL&P) regarding electric generation and cost sharing for new generation. This would require forming a government- to -government, inter-local agreement partnership and then generation and transmission of electricity into the local municipal electric grid. The renewable energy generation systems would have to be either or, large commercial wind power and multi-mega watt biomass steam turbine electric power.

Discussions and analysis was conducted for consideration of selling electricity into the REA (Rural Electric Coop.) green power market. Recent State of Michigan legislation provides for renewable energy credit (REC's) system that formalizes the ability of the regulated utilities to offer REC contracts and payments to independent renewable energy generators. This REC payment is set by a competitive process that will result in payment of +/- 2 cents per kW-hr, which is then added to the real-time electric market price, which will vary from 4 to 6 cents per kW-hr. Since the recent Michigan legislation has set a renewable energy portfolio standard (RPS) of ten percent for its regulated utilities the rural cooperatives in the GTB region are required to seek more green power via this mechanism or other approaches. Presently the two rural distribution cooperatives in the GTB region are marketing their own green power at a price premium, under their generation cooperative Wolverine Power Supply Cooperative. This same situation exists with the investor owned utility in the GTB region, and with the municipal utility included, there are three competing utility organizations offering a range of opportunities. Each situation will require a "special contract" that will have to be assessed as GTB determines the best renewable energy alternatives to suit the interests of the Tribe.

Tribally owned renewable energy generation from wind, solar and biomass qualify for the ten year, renewable energy production incentive payment (REPI) which is presently at 2 cents per kW-hr produced, increasing with inflation. This is a direct payment from the federal government. The payment fund however, must be authorized by congress periodically and in recent years it has been under funded. There is some risk that the money will not be available. However, with the new government administration in 2008 the program is more likely to be adequately funded. Wind power has first priority for payments under this program and energy generated will be banked for future payment if and when funding is available.

Native Energy carbon credits have been analyzed to determine the value of this transaction. Native Energy is a national (and recently international) green marketing organization that purchases "carbon off-sets" from renewable energy projects. This is either a direct cash payment upon commissioning of a qualified project or a payment over time, based upon the energy generation. A single large wind turbine installation, costing over $3 million, could qualify for a cash payment of $40,000 or more upon commissioning. Presently this carbon off-set market could amount to roughly 1 cent per kW-hr for wind power over a ten or twenty year period, depending upon the term of the agreement.

Environmental Evaluation

Analysis on emission offset potential of renewable energy options shows a range of environment benefits depending upon the final selected renewable technologies. Wind power and solar electric power provide nearly a 100% pollution offset from the present electric power generation in the region--which is predominantly coal fired generation. Biomass electric generation has direct offsets of SO_2 and Hg (mercury), and a net zero CO_2 balance resulting from photosynthesis. Renewable energy heat generation from solar thermal or biomass heating systems will offset either coal fired electricity (electric hot water heating), LP gas or natural gas.

Preliminary meetings with a regional environmental organization conducting environmental carbon offset impacts (SEEDS) were held regarding future environmental evaluations when specific renewable energy systems are selected.

Should the Tribe achieve 100% displacement of its fossil energy use, preliminary estimates of CO_2 emission reductions exceed 90,000 tons/yr, and for SO_2, roughly 500 tons/yr.

Benefits assessment

A potential jobs benefit has been estimated for various installation options. The Renewable Energy Policy Project, a national non-profit organization that analyzes and reports on renewable energy policy impacts has prepared a job benefits evaluation methodology. This methodology will be applied to the GTB renewable energy installations when the specific projects are determined by the Tribal Council.

A comprehensive chart (see Figure 12) has been prepared indicating the range of costs and benefits depending on the yet to be selected systems.

Preliminary system designs

Tribal Civil Engineer has conducted a district heat piping preliminary engineering cost review in preparation for further detailed engineering.

Plan to increase community awareness and obtain community support

A public forum was held on September 19, 2006 for GTB members and employees to provide an update on the DOE feasibility study.

Meetings have been held with Tribal leadership to review activities on two occasions and meetings are planned in 2009 for continued review and consideration of next steps.

There have been GTB Newsletter reports and the brochure on Tribal Energy Sovereignty has been prepared and distributed at various venues (see Appendix C).

Presentations were made at the November 5 – 8, 2007 Denver, DOE Tribal Energy Program Review Meeting and at Denver meetings in November 2008.

Long-term operating and maintenance planning

Due to the preliminary nature of the renewable energy systems, with no specific engineered systems, detailed long-term O&M planning tasks were not conducted. In general the operations and maintenance costs for wind turbines and biomass CHP plants are not significant. Two maintenance personnel can handle the service requirements of a relatively large number of wind turbines, for example, up to 30 units. Operating biomass heat and power plants examined for this study typically are staffed with 2 to 4 operations technicians. Typically the plants run at night without staff on site, however, there is remote monitoring capability and automatic emergency notification to operators that are required to be within short time and distance from the plants.

Business and organizational planning for implementing a sustainable renewable energy development

Meetings were held with project advisor Bob Gough to review organization ideas, planning and implementation. Discussions and meetings are planned with various interested parties, such as the local municipal utility to evaluate and consider the appropriate public and/or private project organization.

A contract and agreement flow chart (Figure 13) was prepared to illustrate the possible business and energy relationship between potential partners working with GTB on energy projects.

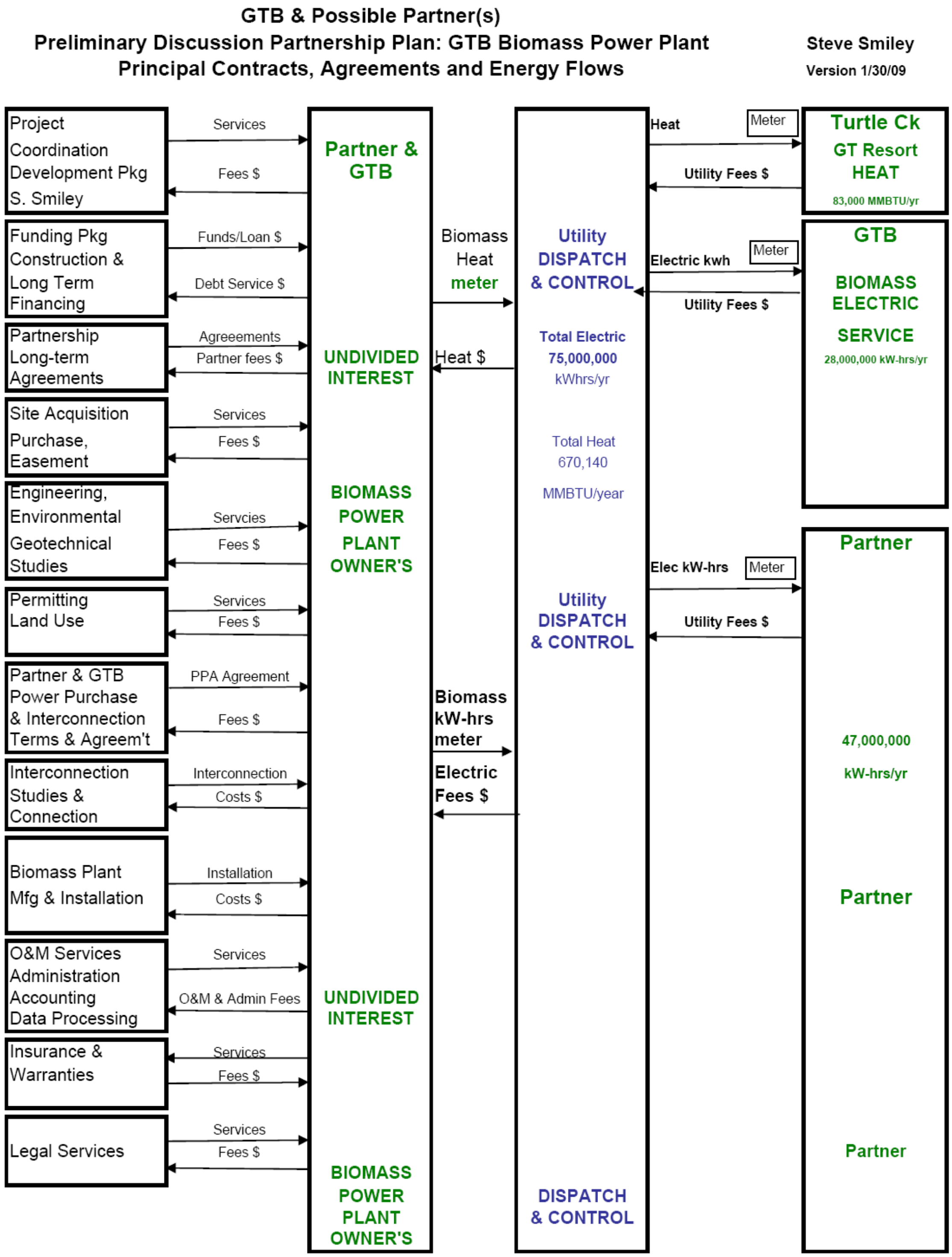

Figure 13 GTB & Possible Partner(s)

Financing plan

Various options are under consideration including Tribal bonds, and if a municipal partnership is formed, for example, the option for municipal revenue bonds exists for funding assistance. For example, a local municipal utility, Traverse City Light and Power (TCL&P), has engaged in its own wind resource study and a memorandum of understanding (MOU) was signed between the GTB and TCL&P to share wind data and the results of the regional wind resource study completed in 2007. A second MOU was signed with the Tribe to share woody biomass data. TCLP is proposing 40 MW of new renewable energy projects specifically for wind and biomass by 2015 and is looking to collaborate with the Tribe to discuss joint venture possibilities.

The Tribe will be seeking funding opportunities through the State of Michigan Department of Labor and Economic Growth-Energy Office, US Department of Agriculture Farm Bill, US Department of Energy-Tribal Energy Program, US Environmental Protection Agency-Combined Heat and Power Partnership, Tribal Pollution Prevention, American Recovery and Reinvestment Act and other sources as applicable.

Financing options will be discussed in up-coming GTB Economic Development Corporation meetings and Tribal Council work sessions.

Summary Conclusions

GTB continues to build their knowledge and experience through this feasibility study and further advances the Grand Traverse Band's Strategic Energy Plan (Appendix D). As a result of the study we now know all of our energy uses for both electric and thermal. We have a better understanding of the 5 utilities, the resources, and technologies available to move the GTB down a path of energy diversification. Although particular energy options were identified they were optimistic and further detailed plans need to be developed based on option selection.

Pending further review and discussions, recommendations will be made to the Tribal Council in 2009 on the appropriate next steps in the Action Plan as outlined in the Grand Traverse Band's Strategic Energy Plan. The following Table 7 illustrates the capital, energy costs and potential renewable energy generation from potential selected installations.

Grand Traverse Band   Dec-08
Integrated Renewable Energy &
Stand-by CHP

	Capital Cost	Energy $ Value / Year	Fuel Expense Per Year	O&M Expense Per Year	Electric KWh/yr	Thermal MMBTU/Yr	Total Energy MMBTU	Total Energy Mega-watt hrs
Wind - 100% Large Commercial	$ 34,200,000	$ 4,137,076	0	$ 523,218	42,000,000	-	143,346	42,000
Biomass CHP Commercial Self-supply	$ 15,749,000	$ 2,390,000	$ 914,000	$ 211,000	26,000,000	83,000	171,738	50,319
Biomass Heat - W. Peshawbestown	$ 1,676,138	$ 95,700	$ 95,700	$ -	-	39,150	39,150	11,471
Solar Thermal Commercial & Residential	$ 2,400,000	$ 104,000	0	$ 60,000	-	3,440	3,440	1,008
	$ 54,025,138	$ 6,726,776	$ 1,009,700	$ 794,218				

Table 7. Integrated Renewable Energy & Stand-by CHP

APPENDIX A

Wind Resource Study of the Grand Traverse Region
July 2007

TRIPOD WIND ENERGY ApS
CONSULTING ENGINEERS

Wind Resource Study of the Grand Traverse Region

Prepared for:

Traverse City Light & Power
1131 Hasting Street
Traverse City, MI 49686

32 pages

27 July 2007

TWE-ref. no. 2.590

TWE-report 070612-1

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1 INTRODUCTION

This report, which is prepared for Traverse City Light & Power (TCLP), includes a wind resource study of the Grand Traverse region.

The present wind resource study is based on high quality wind data, measured at the Grand Traverse (GT) Resort site for one year and at the Long Lake site for nine months. Furthermore, long-term measurements from the Traverse City Airport (TVC) and the Pellston Airport have been applied in the study. The figure below shows the location of the four measurements.

Figure 1 Wind measurements in the region

The wind resource study presents an overall wind resource map for the region and more accurate wind resource maps for the areas at the GT Resort and Long Lake measurements. Furthermore, the expected annual energy productions from wind turbines erected at the GT Resort and Long Lake sites have been calculated.

Please note that the overall wind resource map of the entire region must be considered a very rough estimate only, as it is based on very few measurements resulting in a significant uncertainty.

Therefore, in order to obtain more accurate energy estimates for feasibility studies of possible future wind energy projects, it is recommended to establish additional high quality wind resource measurements at these projects.

2 Available Wind Measurements in the Region

Wind data for the present wind resource study have been available from four measurements in the region.

The measurements have been inspected by Tripod Wind Energy (TWE) during May 2007, and it was found the GT Resort and Long Lake measurements, established by TCLP, fulfil the standard requirements for high quality wind resource measurements. The TVC and Pellston measurements are typical standard meteorological stations.

2.1 Grand Traverse Resort

The GT Resort site is located east of the Grand Traverse Resort, 12 km northeast of Traverse City. The mast location is an open north-south going smooth ridge, which is very suitable for installation of wind turbines from a construction point of view.

The wind conditions are assessed to be very good with a free inflow (see figure 2 and annex 1) from the prevailing wind direction south-west to west.

Figure 2 GT Resort towards west

A 50 m mast was erected in May 2006, and for the present analyses wind data from the following 1-year period has been available:

Available data:	17 May 2006 - 22 May 2007

The main particulars for the measurement are as follows:

Location:	UTM, NAD83 16T (622717, 4959286)
Mast:	50 m tubular, guy wired

Equipment:	Nomad logger, RMY monitor and NRG Max #40 anemometers and 200P wind vane
Wind Speed:	50.5 m (RMY and NRG), 40 m and 30 m (NRG)
Wind Direction:	50.5 m (RMY), 49 m and 28.5 m (NRG)
Recovery rate:	100 per cent (all data)

The following wind vane offsets[1] have been determined by TWE during the inspection:

RMY, 50.5 m:	2°
NRG 49 m:	89°
NRG 28.5 m:	83°

2.2 Long Lake

The Long Lake site is located 7 km northwest of Traverse City. The terrain is an undulating, relatively open area with some forest (see figure 3 and annex 1) and buildings within the neighbourhood.

A 50 m mast was erected in August 2006 and for the present analyses wind data from the following nine months' period has been available:


Figure 3 Long Lake towards west

Available data:	28 August 2006 - 22 May 2007

The main particulars for the measurement are as follows:

Location:	UTM, NAD83 16T (601411, 4958148)
Mast:	50 m tubular, guy wired
Equipment:	Nomad logger, RMY monitor and NRG Max #40 anemometers and 200P wind vane
Wind Speed:	50.5 m (RMY and NRG), 40 m and 30 m (NRG)
Wind Direction:	50.5 m (RMY), 49 m and 29.5 m (NRG)
Recovery rate:	100 per cent (all data)

The following wind vane offsets[1] have been determined by TWE during the inspection:

RMY, 50.5 m:	2°
NRG 49 m:	87°
NRG 28.5 m:	90°

[1] Based on compass bearings of the wind vane boom directions and comparisons between logger readings and wind vane orientation transformed to true north inculding 5° magnetic declination

2.3 Traverse City

A standard 10 m meteorological mast is located at the Traverse City (TVC) air field (see figure 4), about 50 m south-east of the main runway. The terrain is flat and relatively open toward the prevailing westerly wind direction. However, the location is close to the airport buildings, forest areas and Traverse City, and combined with the low mast (10 m), the measured wind is significantly influenced by these surroundings. Therefore, this measurement is not used directly to estimate the wind resource in the region, but only as a long-term reference in combination with the two wind resource measurements.

Nine years of hourly wind speed data has been available covering the following period:

Available data: May 1998 - May 2007

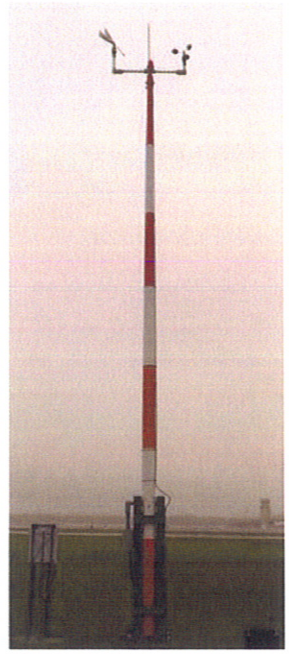

Figure 4 TVC mast

2.4 Pellston

A standard 10 m meteorological mast is located at the Pellston air field (see figure 5), east of the 140°/320° orientated runway. The terrain is very flat and open, and the distance to the nearest airport buildings is about 800 m. Therefore, it is assessed that this measurement can be used to estimate the wind resource in the area as well as a long-term reference.

Figure 5 Pellston mast

However, please note that due to the low measuring height and the neighbouring shed and lattice tower (see figure 5), which must be included in the flow calculations, the estimated wind resource is not as reliable as for a 50 m high quality measurement. Furthermore, the recovery rate, especially of the wind direction data, is low and therefore, the measurement has only been applied as a long-term reference.

Six years and eight months of hourly wind speed data has been available covering the following period:

Available data: August 2000 - April 2007

3 DATA CHECK

The available wind data has been checked by comparison between the wind speed measured at the different heights and furthermore, by comparison between the wind speed measured at the four masts. Likewise, the measured wind directions have been compared (some of the comparisons are presented in paragraph 4.2).

No errors have been found for the GT Resort and Long Lake measurement.

Both the TVC data and the Pellston data are incomplete. Especially the wind direction data is missing during periods. Therefore, the wind direction distributions, measured at these masts, are not applicable for wind resource assessment. However, the measured wind speeds are assessed to be usable for assessment of the wind resource level as well as for long-term references.

The wind speed at GT Resort and Long Lake is measured at the top of the masts (50.5 m) by two different sensors: RMY and NRG. However, the analyses (see figure 6) show that the wind speed measured by the NRG anemometer is 2-4 per cent higher than the wind speed measured by the RMY sensor. The reason is most likely that no specific calibrations have been applied.

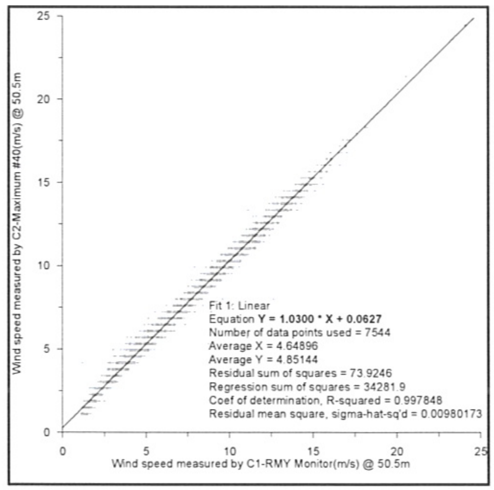

Figure 6 Comparison between wind speed measured by NRG and RMY, respectively

Experience with the NRG anemometers has shown that the individual anemometers differs insignificantly only from the standard calibration expression. No information about the RMY sensors calibration characteristics is available. Therefore, in the presented analyses it has been decided to apply the wind speeds measured by the NRG anemometers only at GT Resort and Long Lake.

4 Wind Analyses

The available wind data is analysed in order to determine the wind distributions, the monthly and daily variations, the wind profiles, the turbulence intensity and the correlation between the measurements.

4.1 Wind Distributions

The measured wind data from the four measurements is transformed into the Weibull distributions (the red curve represents the measured distribution and the green curve the Weibull fit) and presented in the following four figures.

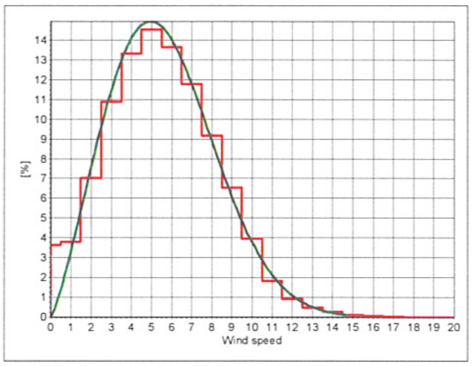

Figure 7 Weibull distribution (m/s) GT Resort, 1 year

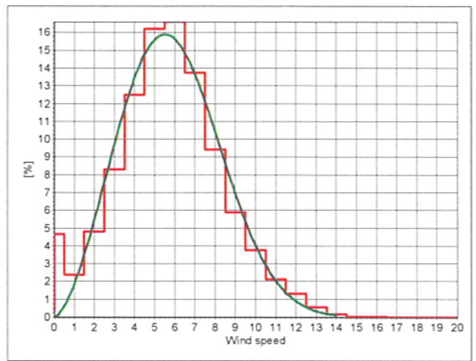

Figure 8 Weibull distribution (m/s) Long Lake, 9 months

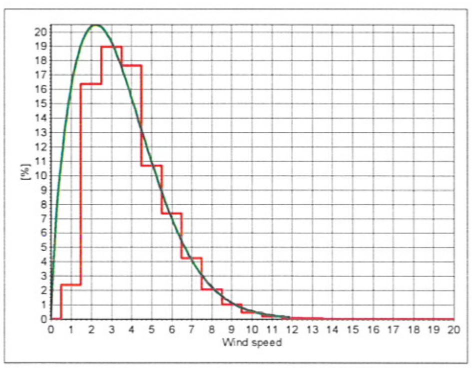

Figure 9 Weibull distribution (m/s) TVC, 9 years

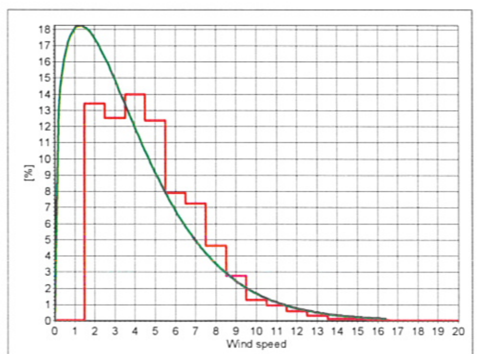

Figure 10 Weibull distribution (m/s) Pellston, 6 years

It is seen from figure 7 and 8 that there is a good agreement between the measured wind distributions and the Weibull fits for the GT Resort data and the Long Lake data, whereas the fits are poorer for the TVC and Pellston data.

The Weibull A and k parameters and mean wind speed for the available measuring periods are shown below.

	Weibull A	Weibull k	Mean Wind Speed
GT Resort, 1 year, 50.5 m	6.4 m/s	2.31	5.6 m/s
Long Lake, 9 months, 50.5 m	6.6 m/s	2.63	5.9 m/s
TVC, 9 years, 10 m	3.8 m/s	1.69	3.4 m/s
Pellston, 6 years, 10 m	4.0 m/s	1.30	3.7 m/s

Please note that the Weibull parameters and mean wind speeds must not be compared directly, as neither the measuring periods nor the measuring heights are not identical.

4.2 Wind Direction Distribution

The wind direction distribution is shown for the GT Resort data only, as the Long Lake measurement covers less than one year and as the wind direction data from TVC and Pellston are incomplete. Figure 11 shows the wind rose (direction in per cent of time) and figure 12 the energy rose (direction in per cent of energy) of the distribution

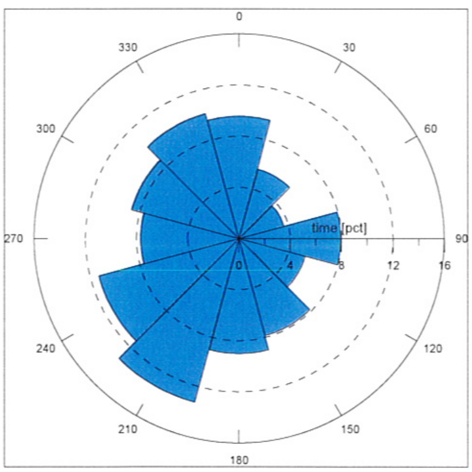

Figure 11 Wind rose at GT Resort

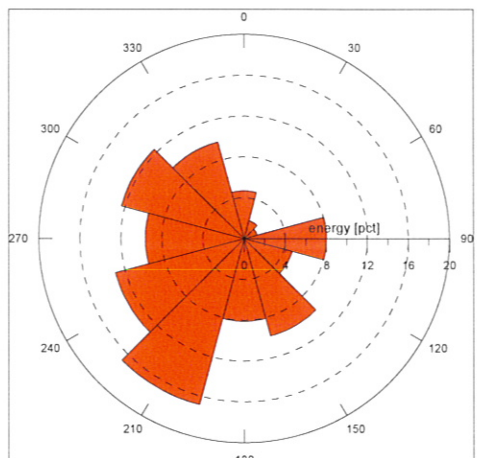

Figure 12 Energy rose at GT Resort

In figure 11 and 12 it can be seen that the prevailing wind direction (time as well as energy) at GT Resort is southwest.

4.3 Monthly and Diurnal Variations

The figures 13-15 show the monthly variations for the GT Resort, TVC and Pellston measurements (Long Lake covers 9 months only).

The figures show a clear seasonal variation, with the highest wind speeds during winter and lowest wind speeds during summer.

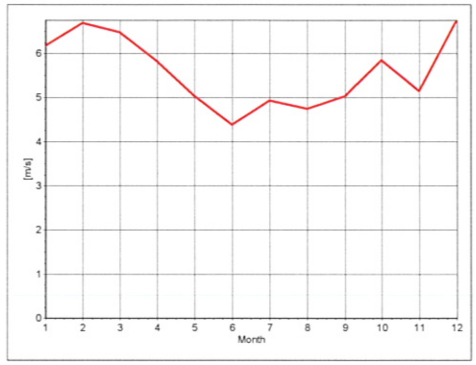

Figure 13 Monthly mean wind speeds at GT Resort (June 2006 - May 2007)

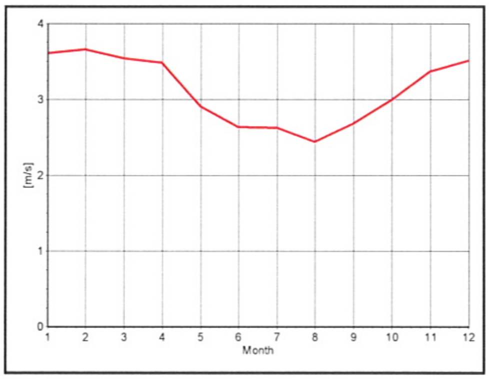

Figure 14 Monthly mean wind speeds at TVC (1998-2007)

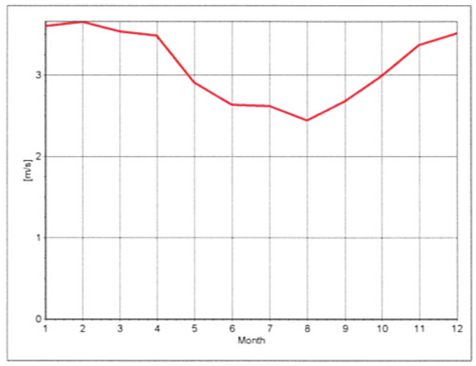

Figure 15 Monthly mean wind speeds at Pellston (2000-2007)

The diurnal variations in the wind speed is shown in figures 16-19 for the four measurements.

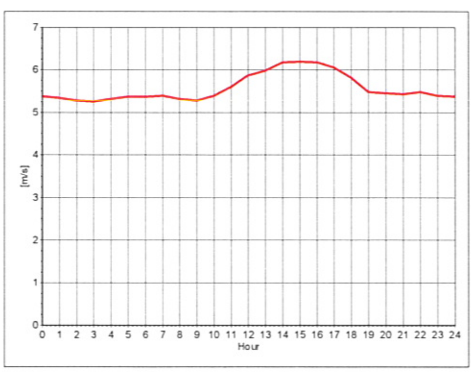

Figure 16 Diurnal wind speed variation at GT Resort

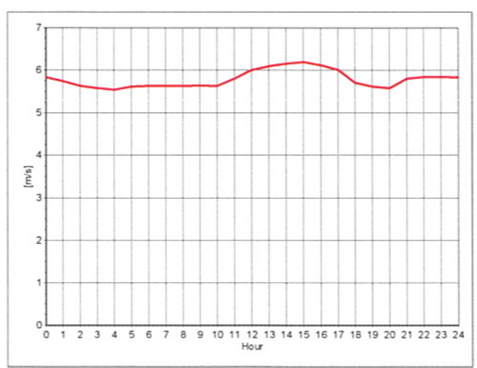

Figure 17 Diurnal wind speed variation at Long Lake

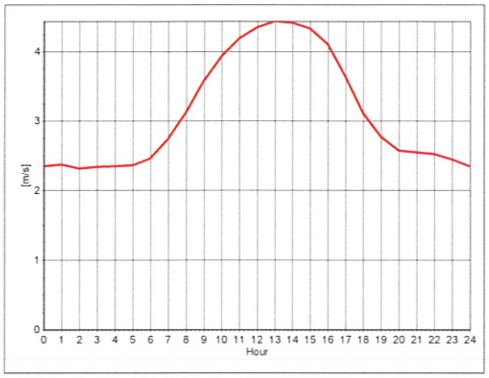

Figure 18 Diurnal wind speed variation at TVC

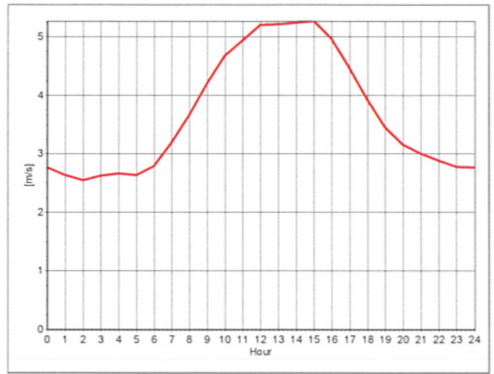

Figure 19 Diurnal wind speed variation at Pellston

From figures 16-19 it can be seen that there is the same tendency of higher wind speeds during daytime at all four locations.

The presented variations in the wind speeds are in agreement with the expected general wind climate for the region, and it indicates that all four locations are exposed to the same general wind climate. This is an important prerequisite for the wind resource calculations presented in this report.

4.4 Wind Profile

Only the GT Resort and Long Lake measurements include wind speed data measured at different heights, making it possible to assess the wind profile.

The wind speed is measured at 50.5, 40 and 30 m above ground level (AGL) at both masts, and the following figures 20-22 show the correlation between these wind speeds at GT Resort for all wind directions.

It is seen that there is not a perfect linear correlation between the wind speed measured at the different heights. The reason is that the wind profile depends on the terrain and consequently, it will vary with the wind direction. Furthermore, the wind speed is disturbed by the mast, especially for the two lower anemometers, when the wind is coming from east (anemometers are pointing towards west).

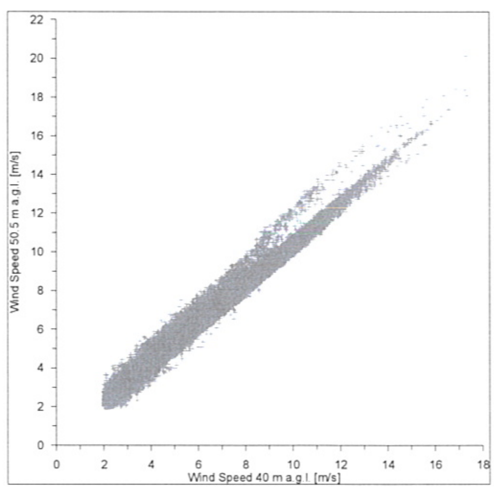

Figure 20 Correlation between wind speed measured at 50.5 and 40 m at GT Resort

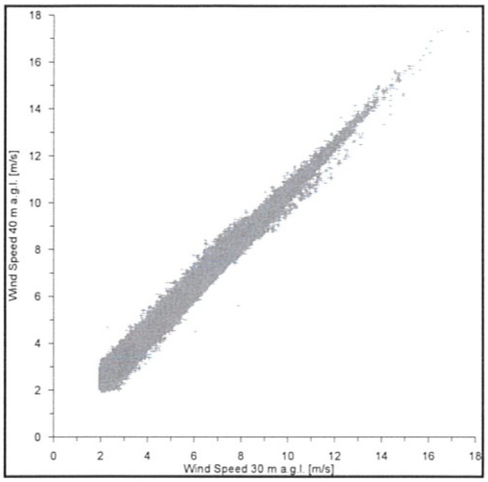

Figure 21 Correlation between wind speed measured at 40 and 30 m at GT Resort

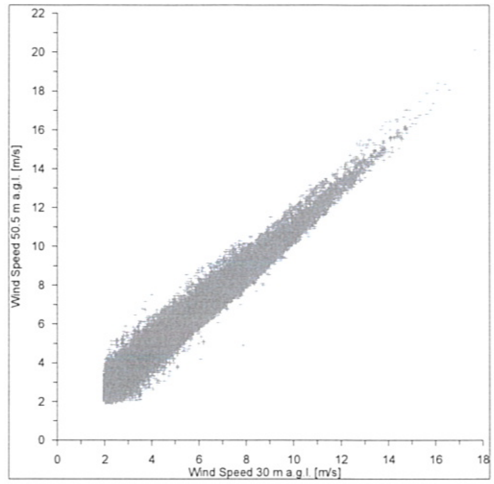

Figure 22 Correlation between wind speed measured at 50.5 and 30 m at GT Resort

The next figures 23-25 show the correlations at Long Lake.

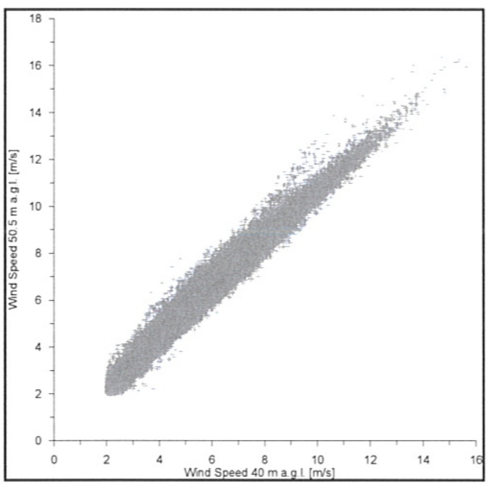

Figure 23 Correlation between wind speed measured at 50.5 and 40 m at Long Lake

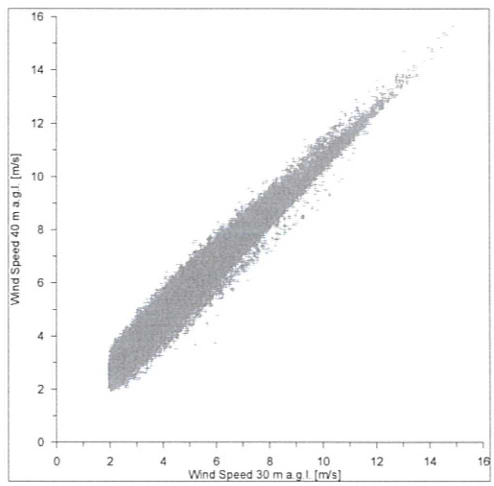

Figure 24 Correlation between wind speed measured at 40 and 30 m at Long Lake

It is seen that the correlations for the Long Lake measurements deviate even more from a linear connection. The reason is that the surrounding terrain at the Long Lake mast includes groves and other vegetation (see annex 1), which disturb the free wind flow.

Therefore, in order to assess the wind shear more thoroughly, 30° sector wise correlation analyses have been carried out for both measurements (annex 2 presents the results for 50.5 and 40 m heights at GT Resort).

The result of the sector wise analyses is presented in the following two figures 26 and 27 showing the wind shear exponent, α, assuming an exponential wind profile between two heights, H1 and H2:

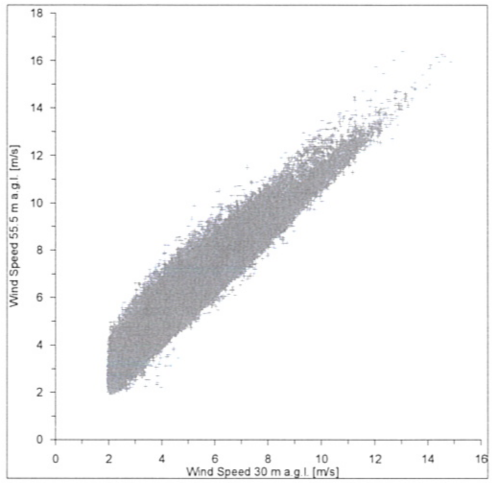

Figure 25 Correlation between wind speed measured at 50.5 and 30 m at LL

$$V_{H2} = V_{H1} \cdot (H2 / H1)^{\alpha}$$

as a function of the wind direction.

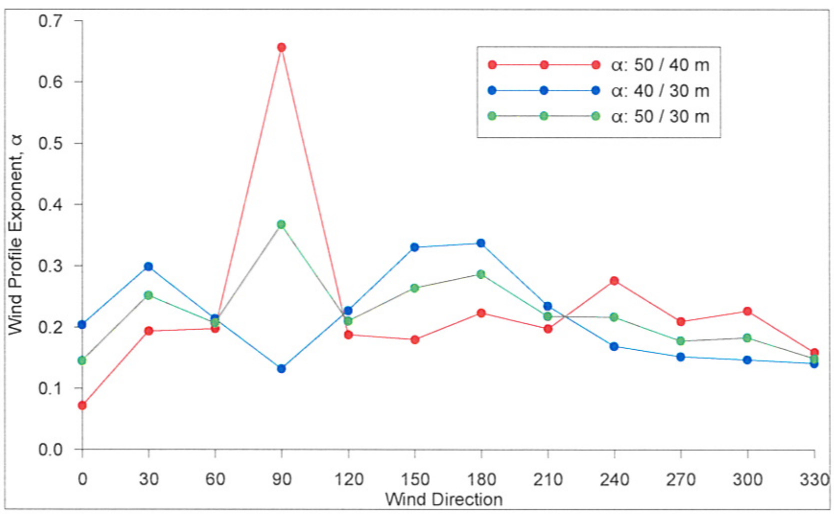

Figure 26 Wind profile exponent, α, as a function of the wind direction at GT Resort

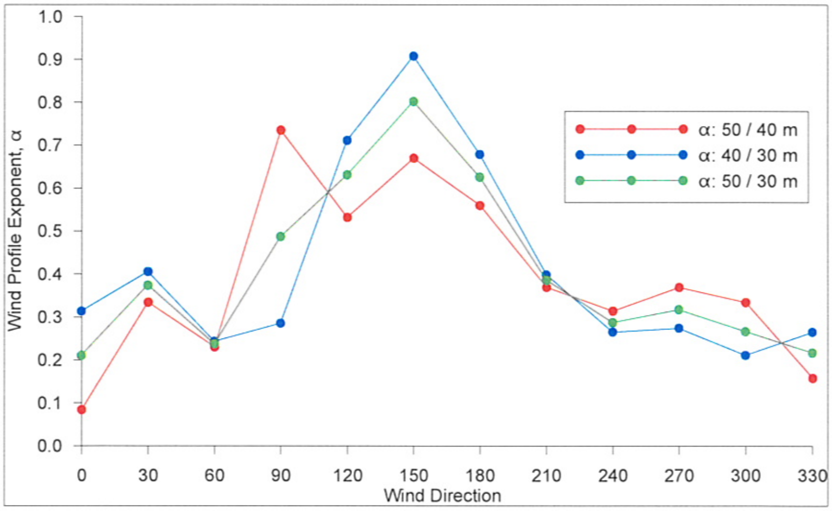

Figure 27 Wind profile exponent, α, as a function of the wind direction at Long Lake

Both figures show that the wind profile exponent, α, including the 50 m wind speed (red and green curves) for 90° wind direction, is very high. The reason is that the 40 and 30 m anemometers are in the 'wake' from the mast, resulting in relatively lower wind speed than at the 50 m top anemometer.

Furthermore, it is seen that the wind profile exponent, α, including the 50 m wind speed, (red and green curves) has a minimum for wind coming from 0°. The reason is that the 50 m NRG top anemometer is in the 'wake' from the RMY sensor.

The very large wind profile exponent, α, at Long Lake for the wind direction between 120° and 200° is caused by the grove, which are located between 60 and 130 m from the mast towards SE-SW.

It should be noted that the very high wind profile exponent figures must not be used to extrapolate the wind speed from 50 m to e.g. 90 m hub height. The wind profile will not follow the same exponential shape above 50 m, where the wind is less disturbed by the surrounding trees. Instead a flow model calculation taking the terrain topography into account must be used.

By excluding the sectors influenced by the mast and sensor disturbances and the sectors including neighbouring groves, the following overall wind shear exponents have been obtained for the two sites:

GT Resort:	α	=	0.21
Long Lake:	α	=	0.31

Based on the terrain roughness at the two sites, a wind shear exponent between 0.13 and

0.17 for the GT Resort site and between 0.20 and 0.25 for the Long Lake site would have been expected. The explanation for the measured wind shear exponents being higher than expected could be the measuring accuracy (calibrations, flow disturbance at the masts etc.). Another explanation could be that the wind profile does not follow an exponential shape, especially below 50 m.

4.5 Turbulence Intensity

The turbulence intensity is defined as the ratio between the standard deviation and mean value of the wind speed during a 10-minute period.

The figures 28 and 29 show the average turbulence intensity at 30 m, 40 m and 50.5 m AGL, measured at GT Resort and Long Lake, respectively.

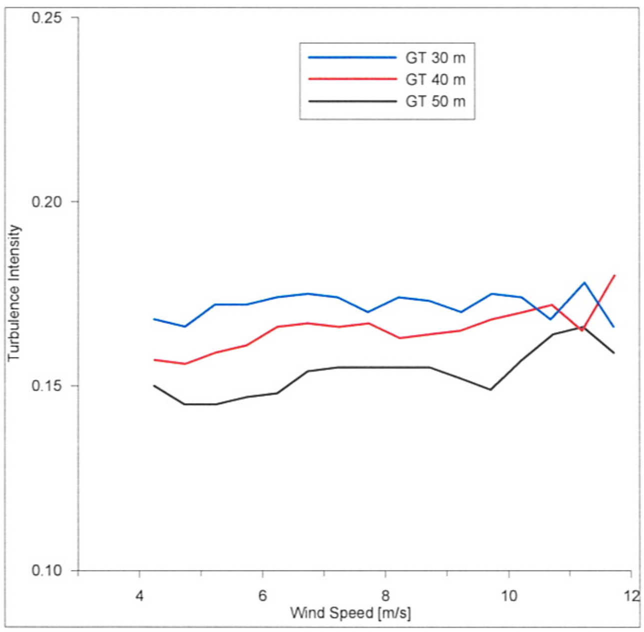

Figure 28 Average turbulence as a function of the mean wind speed 30 m, 40 m and 50.5 m AGL at GT Resort

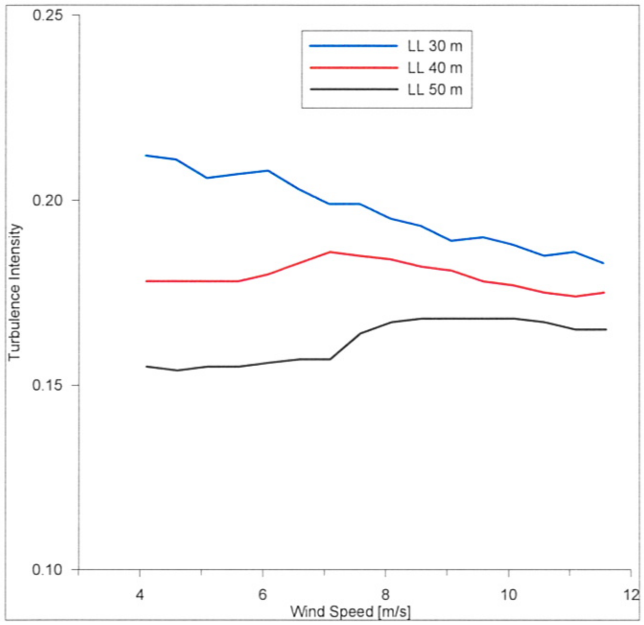

Figure 29 Average turbulence as a function of the mean wind speed 30 m, 40 m and 50.5 m AGL at Long Lake

It is seen that the turbulence decreases, as expected, with the measuring height. Especially the turbulence intensity measured at the Long Lake site at 30 m and 40 m AGL is very high, which is due to the surrounding groves located within 100 m from the mast. The GT Resort site is more open, and therefore the turbulence is lower than at Long Lake.

The average turbulence intensity 50.5 m AGL is for the two sites given by:

GT Resort average turbulence intensity at 50.5 m AGL:	15.3%
Long Lake average turbulence intensity at 50.5 m AGL:	16.2%

4.6 Correlation between the Measurements

The correlation analyses between the measurements are used to assess whether the four locations are exposed to the same general wind climate, which is an important prerequisite for the wind resource calculations presented in this report. Furthermore, the correlation analyses are used to assess the applicability of the long-term corrections, presented in section 4.7.

Due to the long distances between the masts, the correlation analyses are based on daily, weekly or monthly mean wind speeds. The GT Resort measurement has been chosen as reference, and figures 30-32 show the correlations to the other three sites.

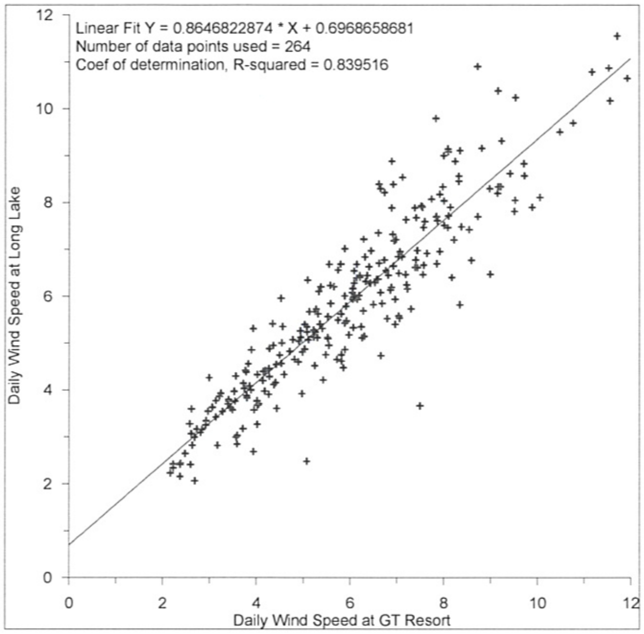

Figure 30 Correlation between daily mean wind speeds measured at GT Resort and Long Lake

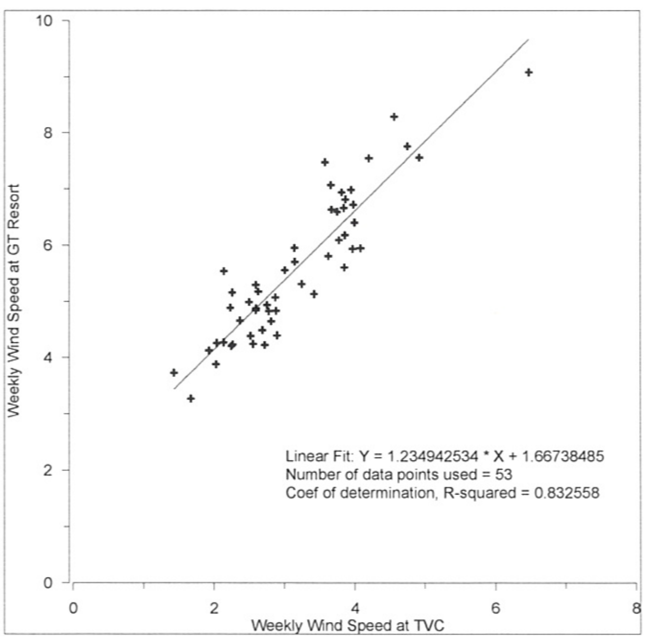

Figure 31 Correlation between weekly mean wind speeds measured at GT Resort and TVC

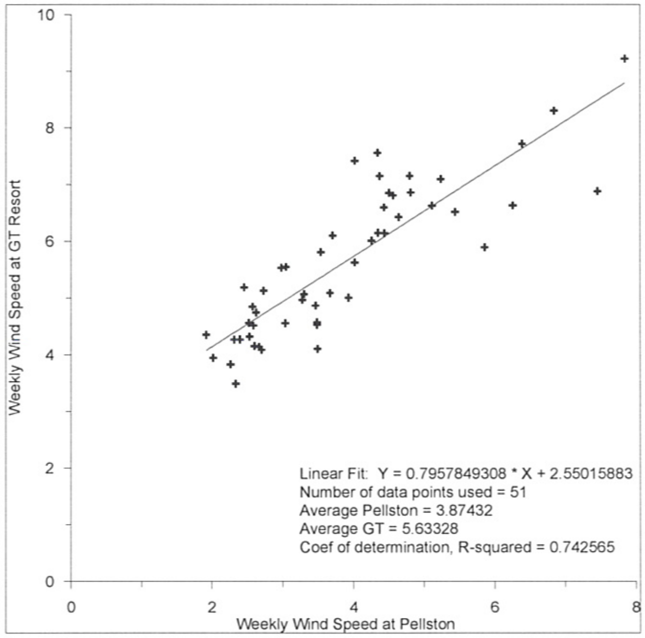

Figure 32 Correlation between weekly mean wind speeds measured at GT Resort and Pellston

It is seen that there are very good correlations ($R^2 = 0.84$) between the daily mean wind speeds at GT Resort and Long Lake and between the weekly mean wind speeds at GT Resort and TVC ($R^2 = 0.83$). As expected, the correlation between the weekly mean wind speeds at GT Resort and Pellston is slightly poorer, due to the longer distance between the two masts. However, a determination coefficient of $R^2 = 0.74$ is acceptable as well.

This result substantiates the assumption that all four sites are exposed to the same general wind climate, which is a prerequisite for the wind resource assessment for the entire region, presented in this report.

Furthermore, it validates the applicability of the long-term measurements (TVC and Pellston) for long-term correction (presented in section 5) of the short-term GT Resort and Long Lake measurements.

5 Long-term Variation

The annual mean wind speeds vary typically corresponding to a standard deviation of 5-7 per cent. This corresponds to a variation of the annual energy production from a wind turbine of 10-20 per cent. Therefore, if the annual energy production estimate from a future wind turbine is based on wind data covering one year only, the result may deviate significantly from the actual long-term annual mean energy production.

5.1 Long-term references

The TVC measurement covers 9 years and the Pellston measurement covers 6 years, and due to the good correlations to the GT Resort short-term measurement, both measurements can be used as long-term references.

However, even the average wind speed during a 9-year period may deviate from a long-term average of 20 years or more. Recent studies have shown that the average wind speed during the 10-year period from 1990-1999 in northern Europe has been about 5 per cent higher than during a period of more than 50 years.

Therefore, NCAR[2] data covering the 30 years' period from 1977 to 2007 has been included for the long-term correction analyses as well. However, it should be noted that due to varying information sources through time, which often results in an increasing or decreasing tendency of the mean level, the NCAR data must be applied with caution and preferably not be used as the only long-term reference. Figure 33 shows the NCAR annual mean wind speeds (black solid curve) and the trend (dotted line) in mean wind speed during the 30-year period. It is seen that there is a slightly increasing trend, which may be due to the inconsistency in the data through time. It has therefore been decided to apply a de-trend of the NCAR data as shown in figure 33 (red curve).

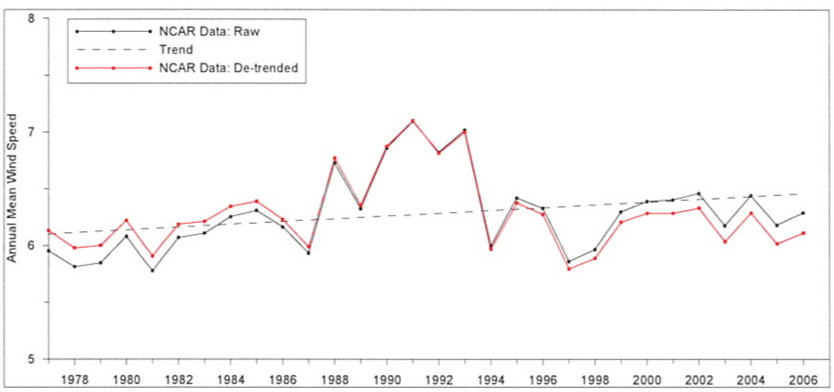

Figure 33 NCAR data 1977 - 2007

Figure 34 shows correlation between the weekly mean wind speeds at GT Resort and based on the NCAR data. It is seen that there is an appropriate correlation, indicating that NCAR data can be applied as an additional long-term reference.

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[2] The NCAR data is re-analysed data based on several different meteorological sources (satellites, balloons, meteorological stations etc.), and covers the entire world with a grid resolution of 2.5 degrees.

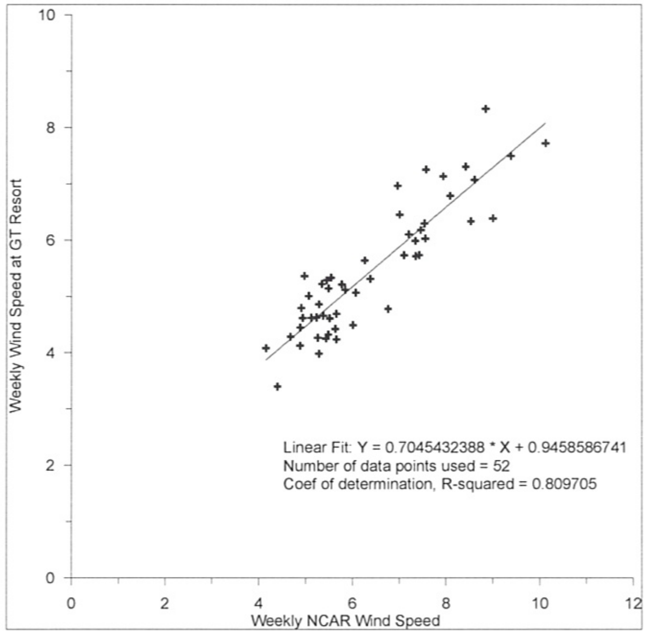


Figure 34 Correlation between weekly mean wind speeds at GT Resort and based on NCAR data

5.2 Extrapolation of Long Lake Data to One Year

In section 4.3 it was shown that there is a considerable seasonal variation of the wind speed. It is, therefore, important to account for this when extrapolating the 9 months' Long Lake data to represent a full year.

There are several methods (called Measure-Correlate-Prediction methods), which can be used to make this extrapolation. The most correct method to apply depends on the available information. With a very good correlation (both wind direction and wind speed) between the GT Resort and Long Lake measurements, it has been assessed that the most correct method is to substitute the missing Long Lake wind data during the period 22 May 2006 to 27 August 2006 with the GT Resort wind data during the same period. The substitution method is as follows.

Based on the weekly correlation analysis, the GT Resort wind speed data, V_{GT}, is transferred, as if it was measured at Long Lake, by the linear expression:

$$V_{LL} = 0.865 \cdot V_{GT} + 0.697$$

This means that if the wind speeds at GT Resort are below 5.15 m/s, the transferred wind speed is higher, whereas if the wind speeds at GT Resort are above 5.15 m/s, the transferred wind speed is lower than at GT Resort. This is in accordance with the actual measured wind speeds at the two sites. During periods with low wind, the wind is slightly higher at Long Lake than at GT Resort, and during periods with high wind, the wind is slightly lower at Long Lake than at GT Resort. Most likely this depends on the actual wind direction. The result is illustrated in the table below, showing the monthly and annual mean wind speeds at GT Resort and Long Lake (transferred data shown bold).

	Jan	Feb	Mar	Apr	Mai	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GT	6.2	6.7	6.5	5.8	4.8	4.4	4.9	4.7	5.0	5.8	5.1	6.7	5.56
LL	5.9	6.0	6.1	5.9	5.1	***4.5***	***5.0***	***4.9***	5.0	5.8	5.1	6.5	5.49

The annual (22 May 2006 - 22 May 2007) mean wind speeds at the two sites are given by:

GT Resort annual mean wind speed at 50.5 m AGL: 5.56 m/s

Long Lake annual mean wind speed at 50.5 m AGL: 5.49 m/s

Due to the good correlation between the wind direction data, measured at GT Resort and Long Lake, the wind direction data measured at GT Resort during the period from 22 May 2006 to 27 August 2006 is transferred directly (without any correction).

5.3 Long-term correction of GT Resort and Long Lake Data

In order to use the one-year GT Resort and Long Lake data as basis for the wind resource assessment, the wind speed data must be corrected according to the long-term references.

Based on the long-term references and the correlations between the measurements, the long-term analyses show that the long-term average wind speed at both the GT Resort and the Long Lake sites is 99 per cent of the annual mean wind speed during the basic measuring period from 22 May 2006 to 22 May 2007.

The long-term annual mean wind speeds at the two sites are then given by 99 per cent of the measured annual mean wind speeds, presented in the previous section:

GT Resort long-term annual mean wind speed at 50.5 m AGL: 5.50 m/s

Long Lake long-term annual mean wind speed at 50.5 m AGL: 5.43 m/s

The corresponding long-term Weibull parameters are given by:

	Weibull A	Weibull k
GT Resort, 50.5 m, long-term	6.3 m/s	2.31
Long Lake, 50.5 m, long-term	6.2 m/s	2.47

6 Wind Energy Resources

6.1 Method

The wind energy resources throughout the Grand Traverse region is calculated by use of the WAsP/WindPro (version 9.0 and 2.5, respectively) flow modelling program. The calculations are based on the Wind Atlas method, which is the most commonly used model today for wind resource assessments.

The Wind Atlas method enables the measured wind data to be transformed to the geostrophic wind conditions for the area, a so-called *wind atlas*. This is done by "cleaning" the data for site specific influence of orography, terrain roughness and local obstacles near the measurement. The *wind atlas* generated is then used to predict the specific wind and energy resources at any position covered by the general geostrophic conditions by applying the specific local terrain description of the predicted site and wind turbine power curve.

The uncertainty of the method very much depends on the complexity of the roughness and orography, on the differences between the terrain conditions at the measuring site and the predicted site, and how well the terrain is described. Furthermore, the uncertainty depends on how well the *wind atlas* represents the geostrophic wind conditions at the predicted site. Therefore, the uncertainty of the predicted wind resource increases for areas with topographies, which are different from the topography at the measurement sites, and increases by the distance to the measurement.

The wind resource is presented by an overall wind resource map for the region and more accurate wind resource maps for the areas around the GT Resort and Long Lake measurements. Furthermore, the expected annual energy productions from wind turbines erected at the GT Resort and Long Lake sites have been calculated. Finally, a comparison between the expected energy production at 9 specific sites is presented.

6.2 Basis information

The basis information for the wind resource calculations is the measured wind data at GT Resort and Long Lake and a digital description of the terrain orography and roughness.

6.2.1 *Wind Atlases*

By use of the WAsP flow model and applying the digital terrain model (see next section), two *wind atlases* are generated.

The long-term corrected GT Resort data and the one-year extrapolated and long-term corrected Long Lake data are applied as basis for generation of the two *wind atlases* representing the general geostrophic wind at the GT Resort and Long Lake sites, respectively.

The wind resources throughout the region is based on these two wind atlases depending on the distance to the two measurements, i.e. the wind resources is calculated as a weighted average based on the distances to the GT Resort and Long Lake measurements.

6.2.2 Digital terrain model

The digital terrain model consists of height curves and roughness description of the terrain.

6.2.2.1 Height Curves

The height curves are 10 m curves for the entire area combined with 5 m curves around the GT Resort site. The higher resolution around the site results in more accurate predictions of the wind resource at the GT Resort site.

As an example the figure below shows a 3D plot of the GT Resort site.

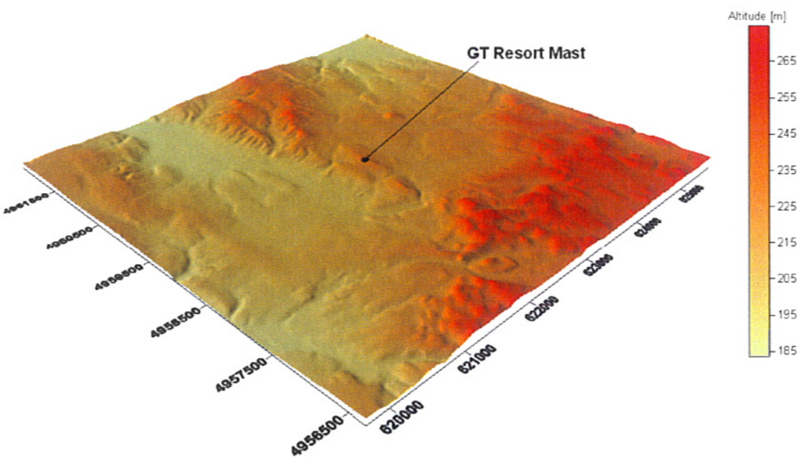


Figure 36 3D plot of the area around the GT Resort measurement (altitude is increased by a factor of 2)

6.2.2.2 Roughness

The roughness of the terrain is given by the vegetation, buildings etc. and is divided into the following categories with corresponding roughness values, Z_0:

- Urban areas, $Z_0 = 1.0$ m
- Forest, $Z_0 = 0.8$ m
- Farm land, $Z_0 = 0.1$ m
- Water, $Z_0 = 0.0$ m

The roughness description is based on land-use maps, Google Earth and observations made during the site visit.

The roughness description is more detailed around the GT Resort and Long Lake sites, compared to the remaining part of the entire region. This means that the resource calculation around the GT Resort and Long Lake sites will be more accurate than for the remaining areas. Therefore, if it is decided - at a later stage - to explore other potential sites, it is recommended to improve the roughness description around these sites in combination with on-site wind measurements.

Due to the close distance between the Long Lake mast and the neighbouring groves, these groves have been included as 'obstacles' in the flow calculations.

6.2.3 Wind Turbines

In order to assess the wind energy resources, the expected energy output has been calculated for the following IEC Class III[3] wind turbine models:

- Vestas V90 2.0 MW, hub height: 80 m
- Gamesa G58 850 kW, hub height: 71 m

Based on the temperature and atmospheric pressure measured at Traverse City, the average air density is calculated at:

1.229 kg/m^3 (220 m ASL)

and the power curves have been corrected according to this average air density.

The power curves for the Vestas V90 and Gamesa G58 are shown below.

Wind Speed [m/s]	V90 Power [kW]	G 58 Power [kW]
1	0.0	0.0
2	0.0	0.0
3	0.0	9.7
4	91.0	31.2
5	200.0	78.4
6	362.0	148.2
7	588.0	242.7
8	889.0	368.8
9	1256.0	525.3
10	1637.0	695.0
11	1904.0	796.6
12	1988.0	835.9
13	1999.0	846.8
14	2000.0	849.3
15	2000.0	849.9
16	2000.0	850.0
17	2000.0	850.0
18	2000.0	850.0
19	2000.0	850.0
20	2000.0	850.0
21	2000.0	850.0
22	2000.0	0.0
23	2000.0	0.0
24	2000.0	0.0
25	2000.0	0.0

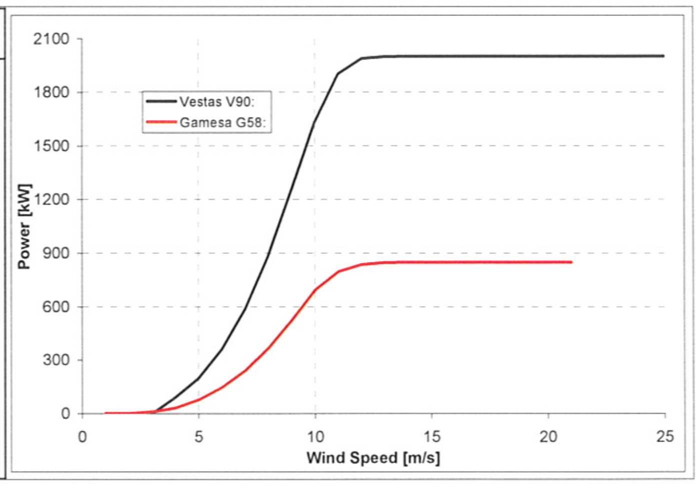


Figure 37 Power curve for Vestas V90 2.0 MW (level 0) and Gamesa G58 for standard air density

[3] Approved for a mean wind speed of 7.5 m/s and a maximum 10 min. wind speed of 37.5 m/s

6.3 Results

6.3.1 Overall Wind Energy Resource

Based on the long-term corrected wind data, measured at GT Resort and Long Lake, and the digital terrain model, the Wind Atlas method has been used to calculate the wind energy resource throughout the Grand Traverse Region.

It should be noted that the calculated overall wind resource must be considered as indicative only, as the uncertainty increases with increasing distance to the measurement. Therefore, if the feasibility of potential sites, located more than 10-20 km from the two existing measurements, is going to be assessed, establishment of additional measurements is recommended.

The result is presented in figures 38 and 39 by the annual mean wind speed at 80 m AGL and by the annual energy output from a Vestas V90 2.0 MW wind turbine (wake loss and other losses are not considered), respectively.

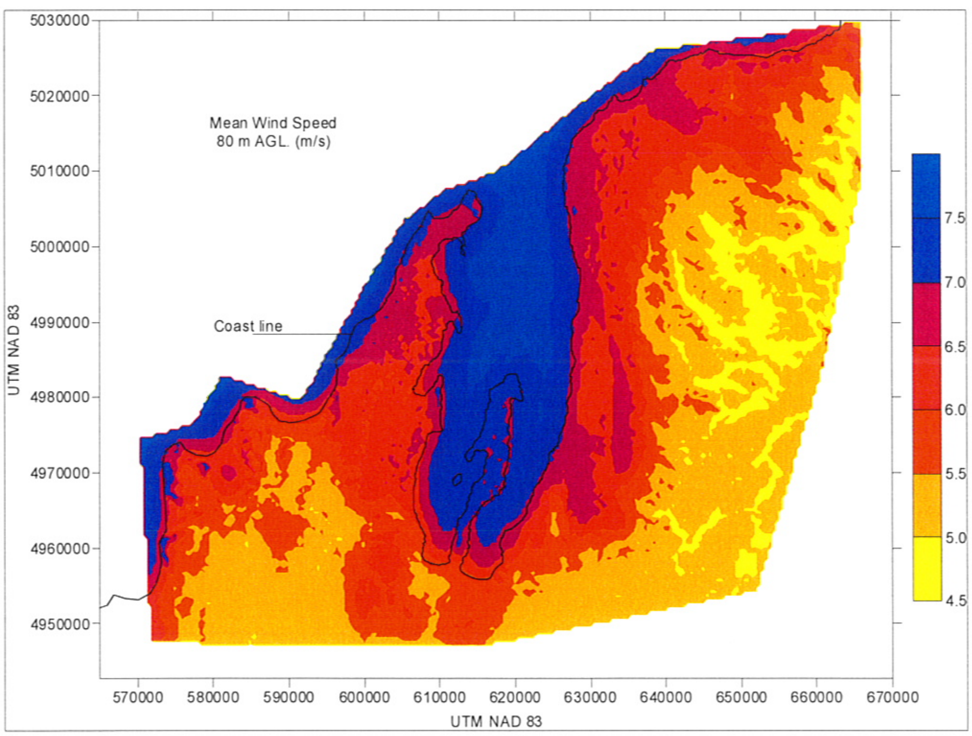


Figure 38 Annual mean wind speed (m/s) 80 m AGL

Figure 38 shows that the annual onshore mean wind speed 80 m AGL varies between 4.5 and 7 m/s, and that the offshore mean wind speed at Grand Traverse Bay is up to about 8 m/s.

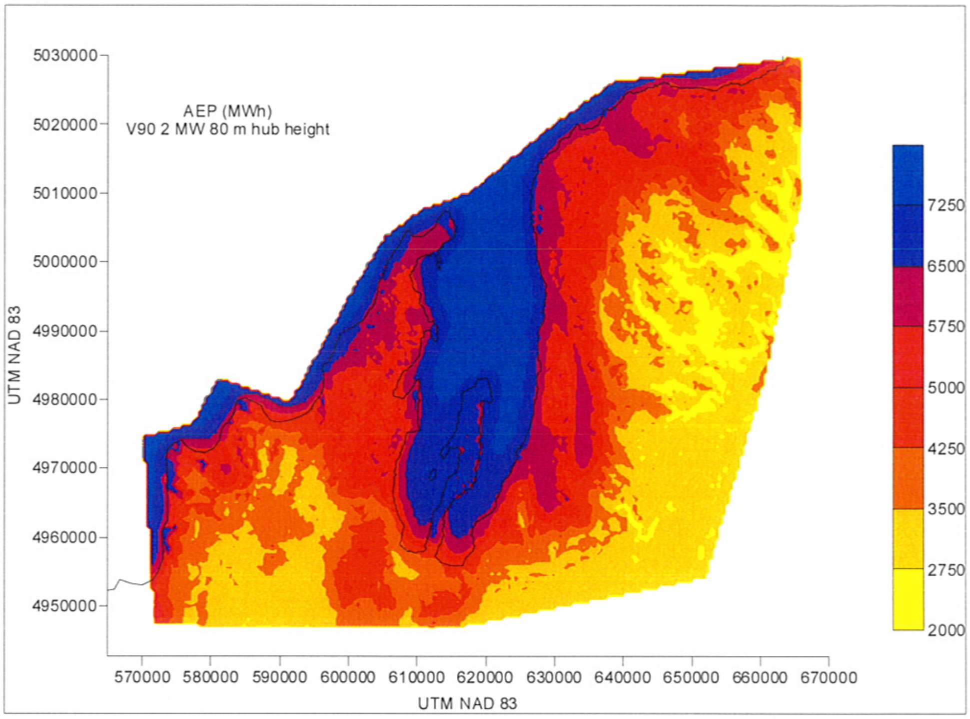


Figure 39 Annual energy output (MWh) from a Vestas V90 2.0 MW wind turbine

Figure 39 shows that the expected annual energy output from a Vestas V90 2.0 MW wind turbine with 80 m hub height placed onshore varies between 2000 and 6500 MWh depending on the location within the region.

6.3.2 Detailed Wind Energy Resources at GT Resort and Long Lake

The detailed wind energy resources at the GT Resort and Long Lake sites are presented by the expected annual energy output from a Vestas V90 2.0 MW wind turbine with 80 m hub height. The result is shown in figures 40 and 41, respectively.

Due to the short distance to the measurement and more detailed terrain description, these results are more accurate and the uncertainty is lower than for the overall wind resource, presented in the previous section.

The positions of the wind turbines, applied in the calculations of the energy production (ref. next section) from 4 wind turbines at GT Resort (Turtle Creek) and 2 wind turbines at Long Lake, respectively, are shown as black dots in the two figures.

It is seen from figure 40 that the energy production can be increased significantly if the wind turbines are located closer towards the lakeside.

At the Long Lake site, where the terrain is undulating and includes lots of groves, the energy resource is highest at the open and higher locations.

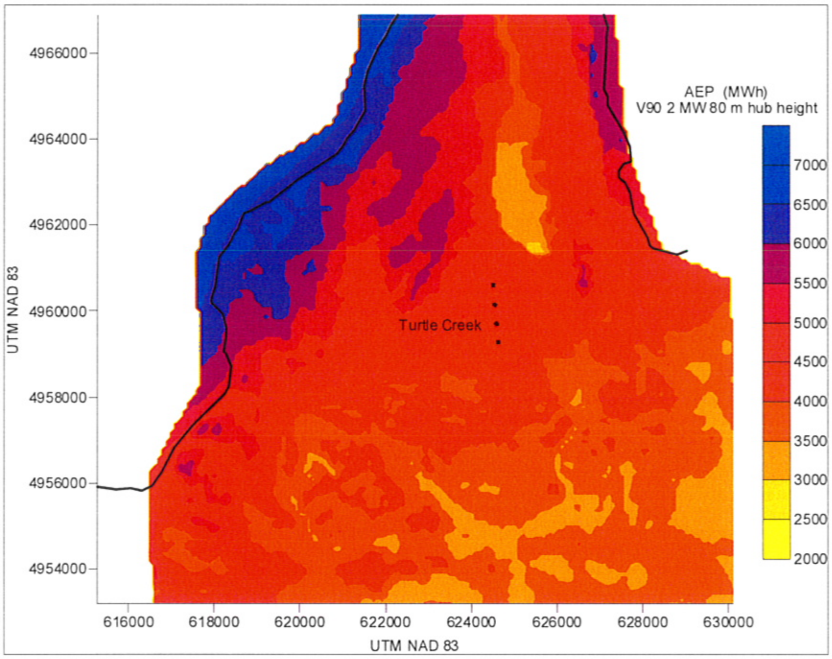


Figure 40 Annual energy output (MWh) from a Vestas V90 2.0 MW wind turbine at GT Resort

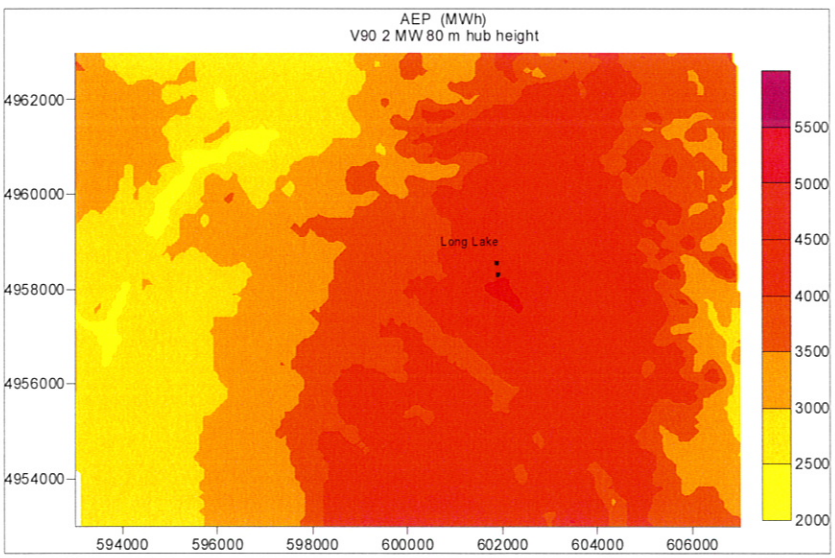


Figure 41 Annual energy output (MWh) from a Vestas V90 2.0 MW wind turbine at Long Lake

6.3.3 Annual Energy Productions at Turtle Creek and Long Lake

The annual energy productions are calculated for 4 wind turbines located at Turtle Creek and 2 wind turbines located at the open area 500 m east of the Long Lake mast. The Turtle Creek site is located approximately 1.8 km east of the GT Resort mast with no major disturbances of the wind flow in between , and therefore it is assessed that the wind measured at the GT Resort mast represents the wind conditions at Turtle Creek.

No micro-siting has been carried out in order to optimise the energy output, as the specific site restrictions are unknown at present. However, the turbines are positioned in a north-south orientated row in order to minimise the wake loss and with a mutual distance corresponding to 5 rotor diameters.

The expected level of annual park production (AEP_{Park}), including wake loss, is calculated using WAsP, based on the GT Resort and Long Lake long-term corrected wind distributions, the power curves and C_T curves for the chosen wind turbines and the digitised map.

	AEP_{Park}	Capacity Factor[4]
Turtle Creek, 4 Vestas V90 2.0 MW	17.38 GWh	24.8 %
Turtle Creek, 4 Gamesa G58 850 kW	6.89 GWh	23.1 %
Long Lake, 2 Vestas V90 2.0 MW	9.19 GWh	26.2 %
Long Lake, 2 Gamesa G58 850 kW	3.48 GWh	23.4 %

Please note that in order to estimate the expected power output to the grid, some loss and correction factors besides the wake loss must be taken into consideration accounting for wind turbine availability, grid availability, transformer and lines loss etc. Depending on the site specific conditions, the combined loss is typically 5 to 8 per cent.

The joint uncertainty on the estimated annual energy productions is given by the combination of the uncertainty of the basic wind distribution, the power curves, the WAsP model and the wake loss calculation. The resulting uncertainty on the presented energy estimates, given as the standard uncertainty corresponding to a confidence level of 68 per cent, is assessed to be within 13-15 per cent depending on the number of wind turbines and the power curve (see annex 3).

[4] AEP_{park} / (installed capacity × 8760 hours)

6.3.4 Comparison between Annual Energy Production at Specific Sites

Nine specific sites, shown in figure 42, have been chosen by TCLP for comparison of the expected energy productions. The calculations have been carried out for a Vestas V90 2.0 MW wind turbine with 80 m hub height, and the results are presented in figure 43.

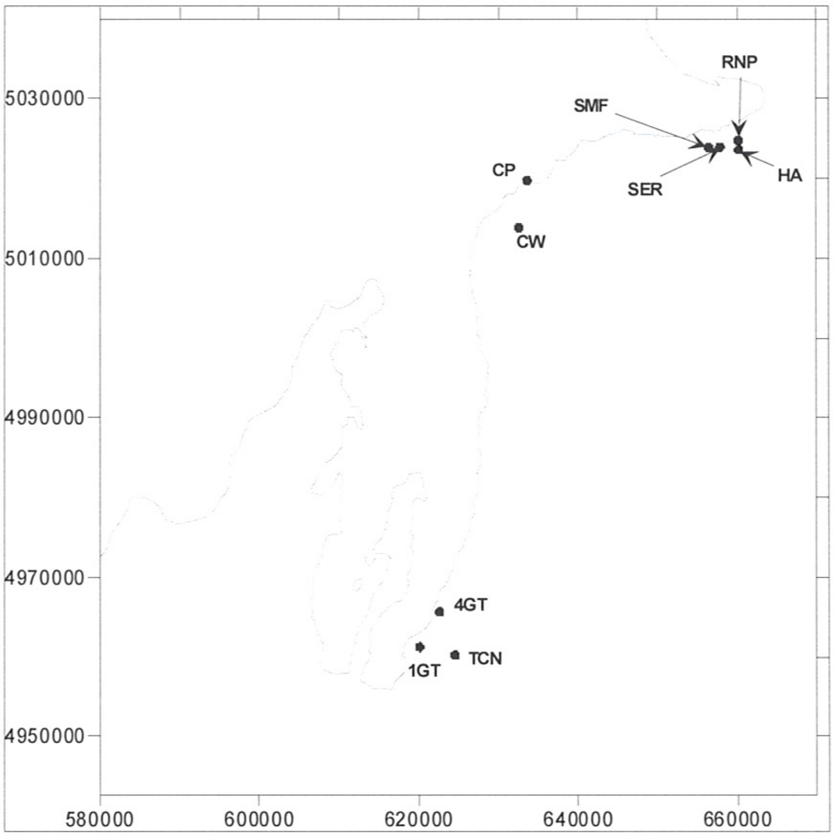


Figure 42 Location of the 9 specific sites

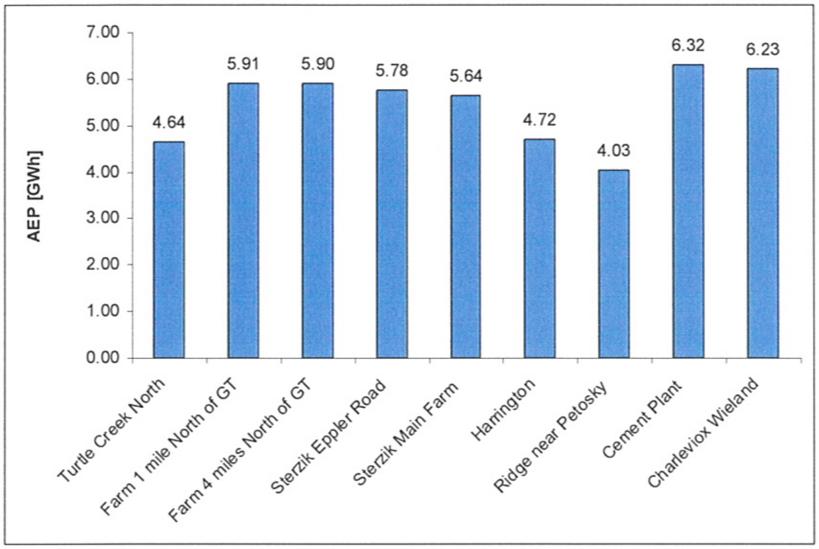


Figure 43 Energy production from a Vestas V90 2.0 MW, 80 m hub height at 9 specific sites

It is seen that the energy production varies from 4.03 GWh at the "Ridge near Petosky" to 6.32 GWh at the "Cement Plant".

However, please note that the energy production depends on where exactly the turbines are located due to the orography (altitude) and on the roughness of the surroundings. Especially the roughness description is not very accurate, which results in a significant uncertainty on the presented production estimates.

- - - o 0 o - - -

Annexes

- Annex 1: Site photos
- Annex 2: Sector wise wind profile analyses
- Annex 3: Uncertainty on AEP estimates

Annex 1 Site Photos

Figure 1 Grand Traverse Resort site north to east

Figure 2 Grand Traverse Resort site east to south

Figure 3 Grand Traverse Resort site south to west

Figure 4 Grand Traverse Resort site west to north

Figure 5 Long Lake site north to east

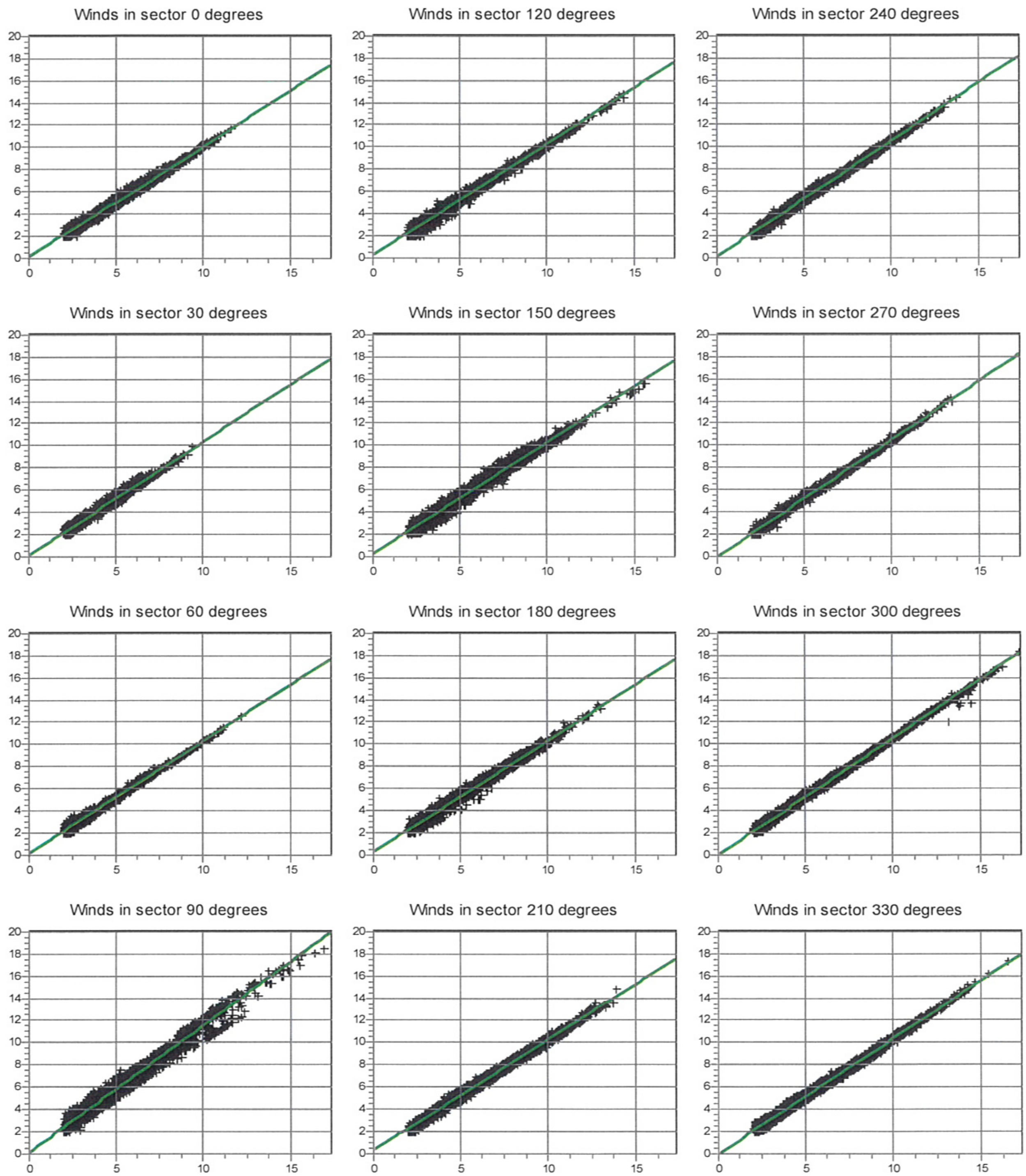
Figure 6 Long Lake site east to south

Figure 7 Long Lake site south to west

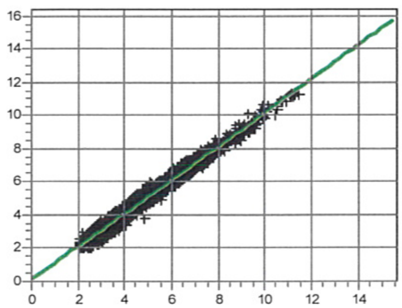
Figure 8 Long Lake site west to north

Annex 2: Sector wise wind profile analyses

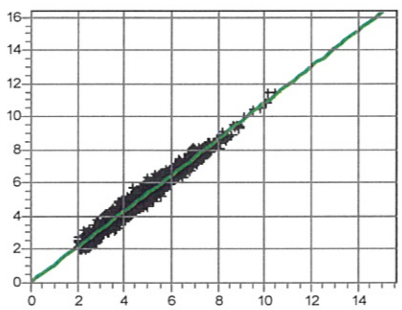
The following figures on this page show the sectorwise correlation between the wind speeds measured at 50.5 and 40m at GT Resort and on next page Long Lake.



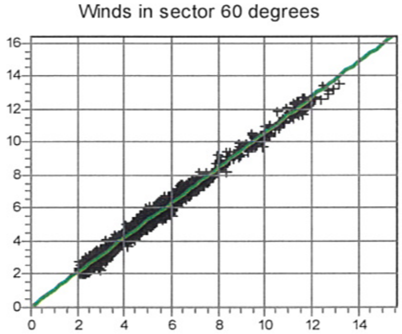
Winds in sector 0 degrees



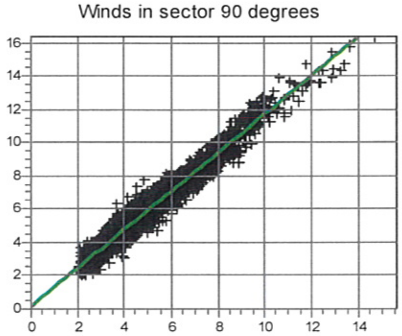
Winds in sector 30 degrees



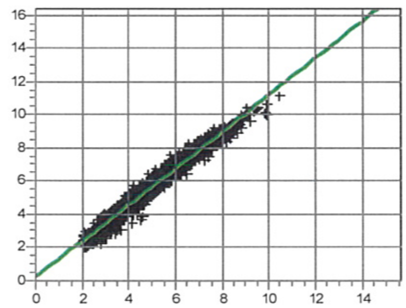
Winds in sector 60 degrees



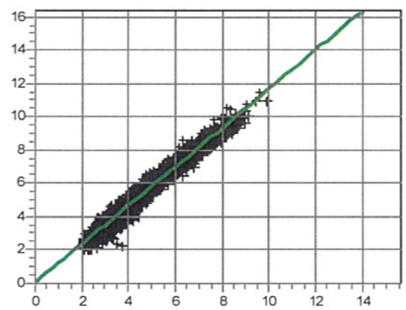
Winds in sector 90 degrees



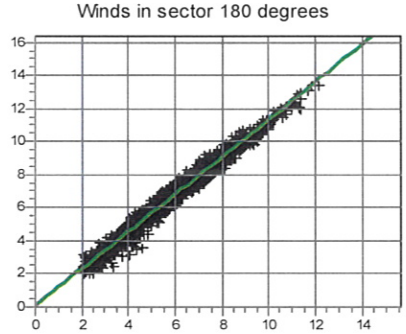
Winds in sector 120 degrees



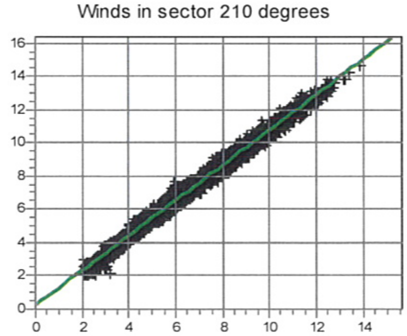
Winds in sector 150 degrees



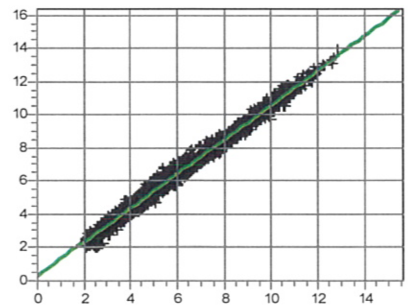
Winds in sector 180 degrees



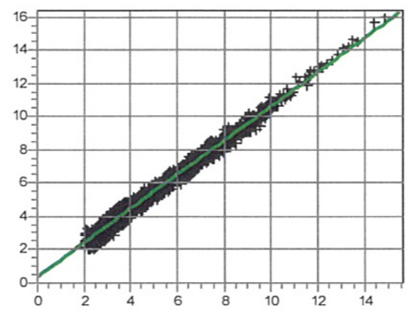
Winds in sector 210 degrees



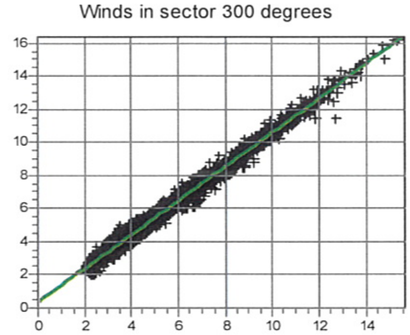
Winds in sector 240 degrees



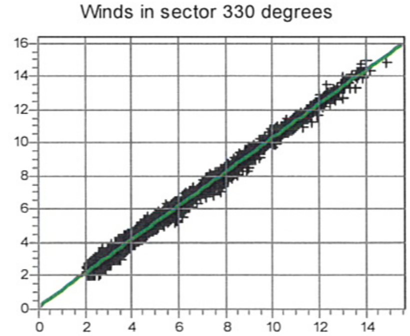
Winds in sector 270 degrees



Winds in sector 300 degrees



Winds in sector 330 degrees



Annex 3 Uncertainties on AEP estimates

The uncertainty of the calculated AEP estimate is determined as a joint uncertainty. The individual contributions are considered uncorrelated and are expressed as standard deviations or as Gaussian distributed maximum limits.

The combined uncertainty of the basic wind distribution is determined, and this is combined with the uncertainty of the power curve, the losses, the WAsP model and the PARK calculation. The resulting uncertainty is given as the standard uncertainty corresponding to a confidence level of 68 per cent.

The estimated uncertainties for the AEP calculations of:

- Turtle Creek, 4 Vestas V90 2 MW
- Turtle Creek, 4 Gamesa G58 850 kW
- Long Lake, 2 Vestas V90 2 MW
- Long Lake, 2 Gamesa G58 850 kW

are shown on the next pages.

Client	TCLP		Printed: 25-07-07
Project	Grand Traverse		Time: 11:01
No. of WTGs	4		page 1/2

MAIN PARTICULARS

Site	Turtle Creek		
Grid reference			
Wind turbines	Vestas V90 2 MW	No. of WTGs	4
Prod. calculations by:			

Uncertainties are given as standard uncertainties, corresponding to a Confidence Level of 68%
Type A uncertainties = std.dev./N^.5   Type B uncertainties = max. limit/3^.5

SHORT TERM WIND SPEED AT ON-SITE REFERENCE (HUB HEIGHT)

	+/-	%
Anemometer offset applied (not known)	+/-	%
Anemometer calibration variation	+/-	2.0 %
Shear exponent	+/-	3.4 %
Other partial contributions		%

LONG TERM SCALING FOR ON-SITE REFERENCE (HUB HEIGHT)

Variation of long term data (based on 16 years Jogimatti data)	+/-	1.1 %
Scaling: 1%	+/-	0.5 %
Other partial contributions		

JOINT UNCERTAINTY ON WIND SPEED AT ON-SITE REFERENCE (HUB HEIGHT)

Joint uncertainty	RMS of all	**s1:**	+/-	4.1 %

POWER CURVE

Measured/Calculated?	Measured	**by**	Manufacturer		**Annex**		
Verified/certified (Y/N)	N	**by**		**Certificate**	**Annex**		
					Annex		
				Table	**Annex**		
Uncertainty on power curve in % of production (max limit = 5% without doc.)					**A**	+/-	2.9 %

PRODUCTION ESTIMATE UNCERTAINTY AT 100% POWER CURVE

Estimated Annual Energy Production (AEP) for a normal wind year {A(nom), C(nom), 100% power curve}	**AEO(nom)**		18458.8 MWh
Lower value for AEO on a normal wind year {Anom - s1, C(nom), 100% power curve}	**AEO(min)**		16604.5 MWh
Uncertainty on production estimate at 100% power curve	**B**	+/-	10.0 %

ON-SITE MODELLING UNCERTAINTIES - DEPENDENT ON NO. OF WTs

Orography speed up, average for site		N/A %
Uncert. orography, PARK (50% of orography impact on mean ws w/o doc): (Calculated as: 50*[(1+.01*%-change in prod. due to hills)^0.33-1] [%])	**C**	0.3 %
Roughness uncertainty, assumed 15%	**D**	7.5 %
Uncert. on wake impact on production for all WTGs (std.dev. per WTG set equal to 50% of the average wake loss)	**E**	0.6 %

Uncertainty of estimated losses	%

RESULTING TOTAL UNCERTAINTY ON PRODUCTION ESTIMATE, std.dev. uncert. level

Joint uncertainty is calculated as RMS of A to E	**+/-**	**12.9 %**

Client	TCLP	Printed: 25-07-07
Project	Grand Traverse	Time: 11:02
No. of WTGs	4	page 1/2

MAIN PARTICULARS

Site	Turtle Creek		
Grid reference			
Wind turbines	Gamesa G58 850 kW	No. of WTGs	4
Prod. calculations by:			

Uncertainties are given as standard uncertainties, corresponding to a Confidence Level of 68%
Type A uncertainties = std.dev./N^.5 Type B uncertainties = max. limit/3^.5

SHORT TERM WIND SPEED AT ON-SITE REFERENCE (HUB HEIGHT)

	+/-	%
Anemometer offset applied (not known)	+/-	%
Anemometer calibration variation	+/-	2.0 %
Shear exponent	+/-	3.4 %
Other partial contributions		%

LONG TERM SCALING FOR ON-SITE REFERENCE (HUB HEIGHT)

Variation of long term data (based on 16 years Jogimatti data)	+/-	1.1 %
Scaling: 1%	+/-	0.5 %
Other partial contributions		

JOINT UNCERTAINTY ON WIND SPEED AT ON-SITE REFERENCE (HUB HEIGHT)

Joint uncertainty	RMS of all	**s1:**	+/-	4.1 %

POWER CURVE

Measured/Calculated?	Measured	**by**	Manufacturer		**Annex**		
Verified/certified (Y/N)	N	**by**		**Certificate**	**Annex**		
					Annex		
				Table	**Annex**		
Uncertainty on power curve in % of production (max limit = 5% without doc.)					**A**	+/-	2.9 %

PRODUCTION ESTIMATE UNCERTAINTY AT 100% POWER CURVE

Estimated Annual Energy Production (AEP) for a normal wind year {A(nom), C(nom), 100% power curve}	**AEO(nom)**		7661.0 MWh
Lower value for AEO on a normal wind year {Anom - s1, C(nom), 100% power curve}	**AEO(min)**		6881.5 MWh
Uncertainty on production estimate at 100% power curve	**B**	+/-	10.2 %

ON-SITE MODELLING UNCERTAINTIES - DEPENDENT ON NO. OF WTs

Orography speed up, average for site		N/A %
Uncert. orography, PARK (50% of orography impact on mean ws w/o doc): (Calculated as: 50*[(1+.01*%-change in prod. due to hills)^0.33-1] [%])	**C**	0.3 %
Roughness uncertainty, assumed 15%	**D**	7.5 %
Uncert. on wake impact on production for all WTGs (std.dev. per WTG set equal to 50% of the average wake loss)	**E**	0.6 %

Uncertainty of estimated losses	%

RESULTING TOTAL UNCERTAINTY ON PRODUCTION ESTIMATE, std.dev. uncert. level

Joint uncertainty is calculated as RMS of A to E	+/-	**13.0 %**

Client	TCLP	Printed: 25-07-07
Project	Grand Traverse	Time: 11:02
No. of WTGs	2	page 1/2

MAIN PARTICULARS

Site	Long Lake		
Grid reference			
Wind turbines	Vestas V90 2 MW	No. of WTGs	2
Prod. calculations by:			

Uncertainties are given as standard uncertainties, corresponding to a Confidence Level of 68%
Type A uncertainties = std.dev./N^.5   Type B uncertainties = max. limit/3^.5

SHORT TERM WIND SPEED AT ON-SITE REFERENCE (HUB HEIGHT)

	+/-	%
Anemometer offset applied (not known)	+/-	%
Anemometer calibration variation	+/-	2.0 %
Shear exponent	+/-	3.4 %
Other partial contributions		%

LONG TERM SCALING FOR ON-SITE REFERENCE (HUB HEIGHT)

Variation of long term data (based on 16 years Jogimatti data)	+/-	1.1 %
Scaling: 1%	+/-	0.5 %
Other partial contributions		

JOINT UNCERTAINTY ON WIND SPEED AT ON-SITE REFERENCE (HUB HEIGHT)

Joint uncertainty	RMS of all	**s1:**	+/-	4.1 %

POWER CURVE

Measured/Calculated?	Measured	**by**	Manufacturer		**Annex**		
Verified/certified (Y/N)	N	**by**		**Certificate**	**Annex**		
					Annex		
				Table	**Annex**		
Uncertainty on power curve in % of production (max limit = 5% without doc.)					**A**	+/-	2.9 %

PRODUCTION ESTIMATE UNCERTAINTY AT 100% POWER CURVE

Estimated Annual Energy Production (AEP) for a normal wind year {A(nom), C(nom), 100% power curve}	**AEO(nom)**		9229.4 MWh
Lower value for AEO on a normal wind year {Anom - s1, C(nom), 100% power curve}	**AEO(min)**		8302.2 MWh
Uncertainty on production estimate at 100% power curve	**B**	+/-	10.0 %

ON-SITE MODELLING UNCERTAINTIES - DEPENDENT ON NO. OF WTs

Orography speed up, average for site		N/A %
Uncert. orography, PARK (50% of orography impact on mean ws w/o doc): (Calculated as: 50*[(1+.01*%-change in prod. due to hills)^0.33-1] [%])	**C**	0.3 %
Roughness uncertainty, assumed 15%	**D**	10.6 %
Uncert. on wake impact on production for all WTGs (std.dev. per WTG set equal to 50% of the average wake loss)	**E**	0.6 %

Uncertainty of estimated losses	%

RESULTING TOTAL UNCERTAINTY ON PRODUCTION ESTIMATE, std.dev. uncert. level

Joint uncertainty is calculated as RMS of A to E	**+/-**	**14.9 %**

Client	TCLP		Printed: 25-07-07
Project	Grand Traverse		Time: 11:04
No. of WTGs	2		page 1/2

MAIN PARTICULARS

Site	Long Lake		
Grid reference			
Wind turbines	Gamesa G58 850 kW	No. of WTGs	2
Prod. calculations by:			

Uncertainties are given as standard uncertainties, corresponding to a Confidence Level of 68%
Type A uncertainties = std.dev./N^.5   Type B uncertainties = max. limit/3^.5

SHORT TERM WIND SPEED AT ON-SITE REFERENCE (HUB HEIGHT)

	+/-	%
Anemometer offset applied (not known)	+/-	%
Anemometer calibration variation	+/-	2.0 %
Shear exponent	+/-	3.4 %
Other partial contributions		%

LONG TERM SCALING FOR ON-SITE REFERENCE (HUB HEIGHT)

Variation of long term data (based on 16 years Jogimatti data)	+/-	1.1 %
Scaling: 1%	+/-	0.5 %
Other partial contributions		

JOINT UNCERTAINTY ON WIND SPEED AT ON-SITE REFERENCE (HUB HEIGHT)

Joint uncertainty	RMS of all	**s1:**	+/-	4.1 %

POWER CURVE

Measured/Calculated?	Measured	**by**	Manufacturer		**Annex**		
Verified/certified (Y/N)	N	**by**		**Certificate**	**Annex**		
					Annex		
				Table	**Annex**		
Uncertainty on power curve in % of production (max limit = 5% without doc.)					**A**	+/-	2.9 %

PRODUCTION ESTIMATE UNCERTAINTY AT 100% POWER CURVE

Estimated Annual Energy Production (AEP) for a normal wind year {A(nom), C(nom), 100% power curve}	**AEO(nom)**		3830.5 MWh
Lower value for AEO on a normal wind year {Anom - s1, C(nom), 100% power curve}	**AEO(min)**		3440.7 MWh
Uncertainty on production estimate at 100% power curve	**B**	+/-	10.2 %

ON-SITE MODELLING UNCERTAINTIES - DEPENDENT ON NO. OF WTs

Orography speed up, average for site		N/A %
Uncert. orography, PARK (50% of orography impact on mean ws w/o doc): (Calculated as: 50*[(1+.01*%-change in prod. due to hills)^0.33-1] [%])	**C**	0.3 %
Roughness uncertainty, assumed 15%	**D**	10.6 %
Uncert. on wake impact on production for all WTGs (std.dev. per WTG set equal to 50% of the average wake loss)	**E**	0.6 %

Uncertainty of estimated losses	%

RESULTING TOTAL UNCERTAINTY ON PRODUCTION ESTIMATE, std.dev. uncert. level

Joint uncertainty is calculated as RMS of A to E	**+/-**	**15.0 %**

APPENDIX B

GTB Energy Efficiency Review

Grand Traverse Band of Ottawa and Chippewa Indians

Energy Efficiency Applications Review

December, 2008

Prepared by Steven Smiley, Project Consultant

~for~

U.S. Department of Energy – Golden Field Office
Tribal Energy Program

OVERVIEW

The Grand Traverse Band energy efficiency opportunities are significant, estimated to be over $1 million dollars annually, or between ten and twenty percent, depending upon the type of home and facility. The following summarizes the overall energy use characteristics of the Tribe:

The GTB energy use (including the new, 2008 Turtle Creek Casino Hotel) is summarized as follows:

- Total Cost: $6 million/year
- Electric Cost: $3 million/year
- Natural Gas Cost: $2.4 million/year
- LP Gas Cost: $600,000 per year
- Electric: 42 million kilowatt-hours per year
- Natural Gas: 2 million ccf per year
- LP Gas: 435,000 gallons per year
- Peak Electric KW: 5,700 KW (Commercial & Public facilities)
- Average Electric KW: 4,800 kW for entire Tribe

The following table illustrates the breakdown energy use in Tribal facilities and homes:

Grand Traverse Band
Breakdown of GTB Energy Use

Year 2005 (w/ 2008 adj)	Electric kW-hrs/yr	Electric Cost / Yr	Natural Gas CCF's/yr	Natural Gas Cost/yr	LP Gas Gal/yr	LP Gas Cost/yr	Total Cost	Percent
Peshawbestown (Commercial/Public)	5,891,286	$ 388,802	144,624	$ 173,549	834	$ 1,084	$ 563,434	9.3%
Peshawbestown Residential W	842,400	$ 75,816	98,150	$ 117,779	39,167	$ 54,834	$ 248,430	4.1%
Peshawbestown Residential E	770,400	$ 69,336	123,553	$ 148,263			$ 217,599	3.6%
Turtle Creek Casino (Comm/Public)	15,513,551	$ 1,035,664	376,024	$ 451,229	-	$ -	$ 1,486,893	24.5%
GT Resort & Spa	12,545,244	$ 878,167	528,570	$ 634,284			$ 1,512,451	25.0%
Traverse City (Commercial/Public)	453,760	$ 40,838	6,954	$ 8,345			$ 49,183	0.8%
Benzie (Admin)	60,585	$ 5,950			5,640	$ 7,896	$ 13,846	0.2%
Benzie (Residential)	381,600	$ 34,344	-	$ -	64,871	$ 90,819	$ 125,163	2.1%
Charlevoix (Admin)	30,560	$ 2,576			3,437	$ 4,812	$ 7,388	0.1%
Charlevoix (Residential)	266,400	$ 23,976	-	$ -	45,287	$ 63,402	$ 87,378	1.4%
Antrim (Residential)	187,200	$ 16,848	-	$ -	31,824	$ 44,553	$ 61,401	1.0%
Balance of Residential	5,745,600	$ 517,104	691,088	$ 829,306	244,184	$ 341,858	$ 1,688,268	27.9%
	42,688,586	$ 3,089,421	1,968,962	$ 2,362,755	435,245	$ 609,259	$ 6,061,436	100.0%

As seen in the table above nearly eighty percent (80%) of Tribal energy use is from residential homes of members (28%), the Turtle Creek Casino Hotel (24.5%) and the Grand Traverse Resort and Spa (25%).

Base upon facility visits and discussions with staff, in general, the public and commercial facilities are very well maintained with professional maintenance and engineering departments that are knowledgeable about energy efficiency applications   All of the maintenance departments appear to make it a standard practice to change out inefficient equipment with higher efficiency equipment when there are repairs or replacement opportunities.

At the casinos and hotels, ambiance, comfort, design and customer satisfaction are a priority. These requirements put a limit on the nature of efficiency retrofits possible in these facilities where energy consumption is largest. For example, how can a slot machine, smoker ventilation and ambience lighting become more efficient? There are, however, incremental changes and control and operation changes that can have a significant impact on energy use. The new Turtle Creek Casino Hotel was designed with efficiency applications in mind, however, the air handling, heating, cooling and ventilation systems are new and still being analyzed for comfort, efficient control and operation.

For residential homes there are many opportunities - however the primary limitation for homeowners is financing and budgeting for the most significant needed retrofits. Since heating (and for some, cooling) costs are much higher than electric costs for most homeowners, (especially those using LP gas or heating oil), energy efficiency improvements should be focused on the building envelope and mechanical systems. In a typical older home roughly fifty percent of the heat loss is from windows, doors and air-infiltration. It is quite expensive to replace windows and doors with efficient retrofits, easily $5,000 to $15,000 in a typical home, and therefore creative energy efficiency financing mechanisms should be considered to help Tribal members.

The U.S. Environmental Protection “Energy Star” web site and program provides excellent advice and recommended measures and practices for consideration: see: http://www.energystar.gov/

In addition, most of the local electric and gas public utilities that serve the regions of the Tribe presently (or will in the near future under State of Michigan requirements) provide some type of residential and commercial energy efficiency analysis service.

It is recommended that the Tribe establish its own energy efficiency program or department to organize and focus its efforts to maximize these opportunities. With an energy cost saving potential of over $1 million per year, with short

payback periods, it would be justified for the Tribe to invest as much as $5 million or more in such programs.
A summary list of the key energy efficiency applications is as follows:

- High efficiency lighting: compact fluorescent lamps, T8 tube lamps with electronic ballasts, LED lamps, daylighting, lighting controls, etc.
- Energy efficient appliances including: refrigerators, dishwashers, clothes washers, clothes dryers, etc.
- High performance windows: R-3 or higher
- Increased insulation: especially examine floor and ceiling insulation opportunities (uninsulated floors are often a large source of heat loss)
- Properly sized and efficient air conditioning
- High efficiency (90% +) furnaces and boilers
- Programmable thermostats (clock thermostats)
- Heating air duct seals and insulation
- Hot water pipe insulation (from domestic hot water and boilers)
- Air leakage sealing: weather-stripping, fireplace doors, dryer vents, plumbing penetrations, attic hatches, sils and band joists, window and door frames, etc.
- Air ventilation heat recovery (especially in tightly sealed homes)
- High efficiency hot water heaters: (super-insulted tanks, pipe insulation, on-demand tank less heaters, flow controls, etc.)

SAMPLE RECOMMENDATIONS WITH COST SAVINGS

1. RETROFIT THE 2'X4'X 4 LAMP FLUORESCENTS LUMINARIES

There are 2'x 4' x 4 lamp T12 fluorescent ceiling troffers throughout the office areas that can be retrofitted with T8 (1" dia) lamps and electronic ballasts. These lamps will provide better lighting quality and operate with roughly 30% less energy and lower air conditioning requirements. Additional lamp and ballast replacement cost savings will be achieved with this retrofit.

Installed Cost:	$40
Energy Cost Savings/yr:	$ 20
Simple payback:	2.0 yrs

2. RETROFIT THE 1'X8' X 2 LAMP F96 HIGH OUTPUT "WATT MISER" FLUORESCENTS

There are 1'x 8' x 2 lamp F96, T12 HO WM (high output 95 watt lamps) fluorescent luminaires in maintenance and work areas. These fixtures can be retrofitted with high output T8 (1" dia) lamps (typically with lamp ratings of 86 watts) and electronic ballasts. These lamps will provide improved lighting quality with a better color rendering index and balanced light on the display areas.

Installed Cost:	$40
Energy Cost Savings/yr:	$18
Simple Payback:	2.2 yrs.

3. RETROFIT THE 1'X8' X 2 LAMP F96 60 W LAMP FLUORESCENTS.

There are 1'x 8' x 2 lamp F96, T12, 60 watt lamp fluorescent fixtures throughout the facilities that can be retrofitted with T8 lamps and electronic ballasts. Some of these lamps are operating 24 hours per day. The T8 lamps typically are rated at 59 watts and with the electronic ballast, operate at about 25% less electric consumption with improved lighting quality.

Installed Cost:	$40
Estimated Energy Cost Savings	$ 11 / yr.
Simple Payback (yrs)	3.7 yrs.

4. RETROFIT OR REPLACE THE 1'X4' X 2 LAMP F34 FLUORESCENTS.

   There are 1'x4' x 2 lamp strip fluorescents in various areas in the commercial and public facilities and maintenance departments that can be retrofitted with T8 lamps and electronic ballasts. These lamps will provide improved lighting quality.

Installed Cost:	$35
Estimated Energy Cost Savings	$11 / yr.
Simple Payback (yrs)	3.2 yrs.

5. REPLACE THE EXIT SIGNS WITH LIGHT EMITTING DIODE (LED) SIGNS.

   There are many exit signs that can be replaced with new models that have light emitting diodes (LED) with electric ratings of approximately 2 watts, in contrast to the typical 2 lamp X 20 (or 25 watt) watt fixtures. The LED signs have lamp lifetimes rated at up to 10 years, providing significant replacement cost and maintenance savings.

Cost:	$50
Estimated Energy Cost Savings	$20/ yr.
Simple Payback (yrs)	2.5 yrs.

6. REPLACE THE 100 WATT "A" LAMPS WITH 23 W CFL'S.

   There are many 60 to 100 watt incandescent "A" lamps throughout the facilities. These lamps can be replaced with compact fluorescent lamps of 16 to 23 watts, depending on the lighting and fixture requirements. In addition, there are some exterior 100 w lamps that can be replaced. The replacement compact fluorescent lamps should be rated for exterior and cold weather use. Lamp replacement cost savings are also included and significant.

Installed Cost:	$4
Annual Energy Cost Savings:	$23
Simple Payback:	0.2 yrs.

7. REPLACE REFRIGERATORS WITH HIGH EFFICIENCY MODELS.

   Refrigerators in all areas, commercial, public and residential, can be replaced with an “Energy Star” high efficiency model that consumes roughly 50% of the energy of the existing models. Consider a model that operates on less than 2 kW-hrs per day (60 kW-hrs/mo.). Consult the Energy Star rating sheet and examine the various models for the most appropriate fit.

Installed Cost:	$600
Annual Energy Cost Savings:	$ 52
Simple Payback:	11.6 yrs.

8. REPLACE ALL 400 WATT MERCURY VAPOR LAMPS WITH EFFICIENT HID METAL HALIDE LUMINAIRES.

   There are 400 watt mercury vapor high intensity discharge (HID) lamps in various areas that can be replaced with new efficient HID metal halide (MH) lamps and ballasts rated at 225 watts to 250 watts. These lower wattage MH lamps will provide similar lighting levels and much better lighting quality in terms of the CRI (color rendering index). New fixture placement may be considered. Consult a lighting expert to determine the best retrofit options.

Installed Cost:	$ 185
Annual Energy Cost Savings:	$ 91
Simple Payback:	2.0 yrs.

9. EXAMINE ALL NEON SIGNS FOR REPLACEMENT WITH LED DISPLAYS.

   Neon signs of all types used for advertizing and displays consume large amounts of electricity. Many new LED (light emitting diode) applications are now available that can provide colorful displays and background lighting applications at a small fraction of the electric use with long life and durability. For example, a typical small neon sign can use 250 watts/hr, compared to a similar LED display using 20 watts/hr. With 24 hour use this amounts to an electrical savings of over 2,000 kW-hrs per year or roughly $160 dollars per year.

10. REPLACE ALL SINGLE PANE AND OLD DOUBLE PANE WINDOWS.

All single pane glass and aging double pane glass windows should be replaced with high performance (R-3 +) glass windows. In office areas and homes, operating pre-hung glass units can be installed. In the service areas, fixed glass units can be installed. Although the simple payback on investment is relatively high, quality, comfort and appearance issues make this a high priority item. The per square foot estimated cost and energy cost savings is as follows, varying with fuel cost and type in each facility.

Estimated Installed Cost:	$25 per sq. ft.
Energy Cost Savings:	$1 - $2 /yr.
Simple Payback:	11 – 23 yrs.

11. EXAMINE AND CONSIDER HVAC CONTROL MODIFICATIONS AT THE TURTLE CREEK CASINO AND HOTEL

Base on discussions with the building operations engineer, the new Turtle Creek heating, cooling and ventilation (and smoker air control system) system is operating without the controls optimized for the most efficient operation. In the present operating mode, 100% of building air is exhausted and replaced with heated and cooled air, operating in an inefficient mode. Managing and optimizing this system will provide significant energy savings at this new facility - that otherwise has been built with many energy efficiency considerations. At present energy use levels, surprisingly, it appears the new Turtle Creek energy use will exceed that of the Grand Traverse Resort and Spa.

ENERGY EFFICIENCY PRACTICES

This section discusses low cost or no cost practices regarding the efficient operation and the proper maintenance of equipment and systems in your building. These practices should be the first and most important step in an energy management program for your facility. The savings produced can help finance future energy conservation projects. Plus, many of these practices will help prolong equipment life and minimize down-time, which saves money as well as improving productivity. We have not included any savings estimates for these suggestions since equipment and systems usage is so variable. However, generally, investment paybacks are very quick and practices can be implemented by employees, maintenance personnel, or licensed service contractors if necessary.

KEEP LIGHTING FIXTURES, LAMPS AND REFLECTORS CLEAN

When lamps and reflective surfaces become dirty, light output is reduced. Bulbs with an insulating layer of dust will overheat and this can reduce lamp life. By implementing a periodic cleaning program, lighting levels can be increased and the potential for reducing the number of lamps for proper illumination may result.

REPLACE YELLOWED LENSES, DIFFUSERS OR GLOBES

When lighting fixture lenses, diffusers or globes become hazy or yellow, light output is reduced. Replacing these with new, preferably acrylic types, will increase lighting levels and may allow removal of some lamps while still providing adequate lighting.

UTILIZE DAYLIGHT AND TURN OFF LIGHTS IN UNOCCUPIED AREAS

Where possible, utilize natural lighting from windows by design and placement of work and display areas. Incandescent and fluorescent lights should be turned off whenever an area is left unoccupied for any length of time.

HEATING, VENTILATION & AIR CONDITIONING EFFICIENCY MAINTENANCE

These systems should be tested and tuned annually, at minimum, to ensure efficient operation of the systems. Clean condenser and evaporator fins on air conditioning units and heat exchange coils, filters, motors and fans on heating and refrigeration units. Properly adjust controls. The energy saving resulting from good maintenance practices can offset normal maintenance costs and extend the life of your equipment.

APPENDIX C

Tribal Energy Sovereignty brochure

Renewable Energy Feasibility Study

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The GTB Strategic Energy Plan

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Strategically Integrating Renewable Resources

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Energy Sovereignty

↓

Energy Security

Meaningful Job Opportunities

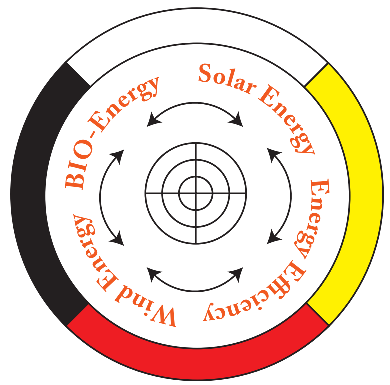
Sustainable Resources

Benefits Seven Generations

"Sovereignty" The Path To Energy Independence

Renewable Energy Feasibility Study

Grand Traverse Band Natural Resources Department

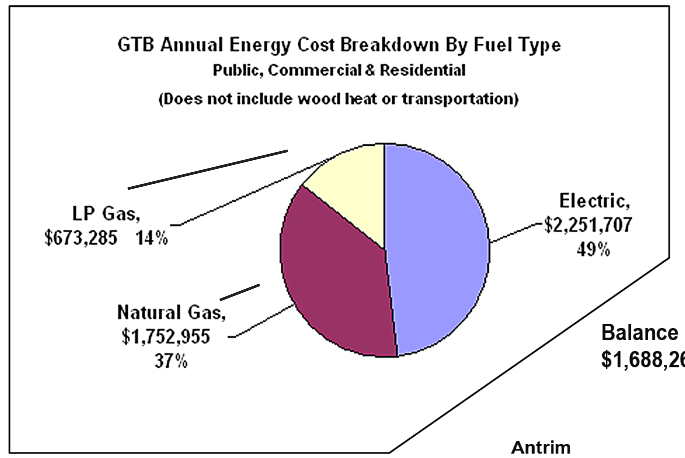


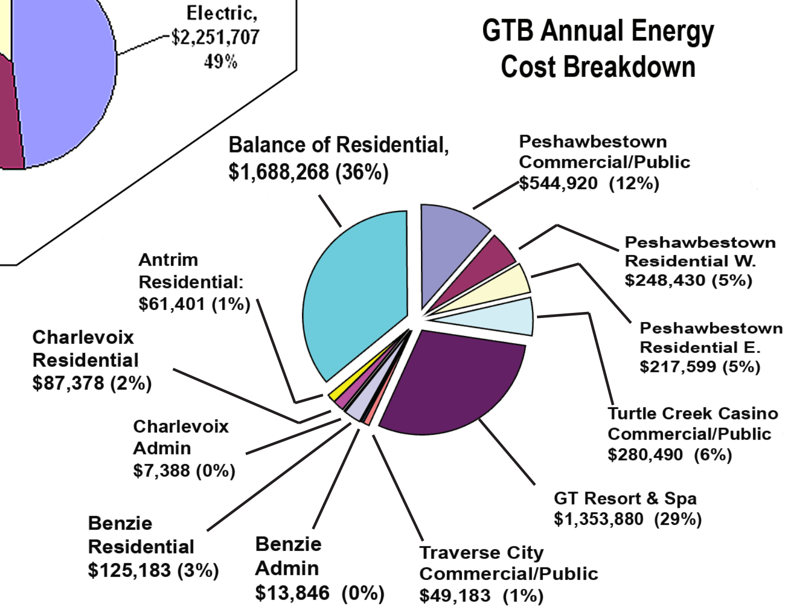
GTB Natural Resources Department
2605 N. West Bay Shore Dr.
Peshawbestown, MI 49682
231-534-7500

This material is based upon work supported by the U.S. Department of Energy under award No. DE-FG36-05GO15182.

Project Goal: To conduct a feasibility study to determine the cost effectiveness and other economic, environmental, cultural and social benefits of maximizing the diversity of energy sources used at GTB facilities.

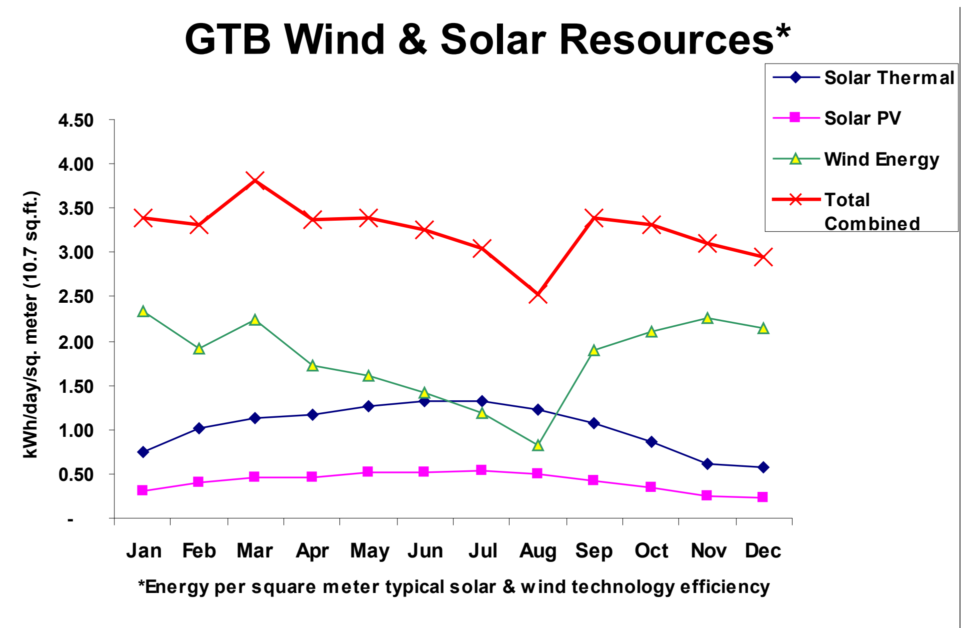
- **Project Activities**
  - Tribal energy loads assessment
  - Evaluate potential for energy efficiency measures
  - Power market assessment
  - Site specific resource monitoring
  - Transmission and interconnection considerations
  - Technology analysis
  - Economic analysis
  - Environmental evaluation
  - Benefit assessment
  - Preliminary system designs
  - Plan to increase community awareness & obtain community support
  - Long-term O & M planning
  - Business organizational planning for renewable energy development
  - Financing plans





Viable GTB Renewable Energy Options

* Solar Thermal
* Passive Solar Design
* Large Scale Wind Power
* Solar Electric (photovoltaics)
* Small Scale Wind Power
* Biomass (wood and crops)
* Economic integration of renewable energy
* Energy efficiency, District Heat & Combined Heat & Power



Our high quality wind resource study has given us detailed information about the winds here in the Grand Traverse region. It is significant to note that our winter wind resource tapers off as the summer solar resource gains strength. Overall we could expect a stable Total Combined Energy Resource when these two are paired up.

Biomass & Solar:
100 Residences

Biomass Community Heating

Wind Resource Study at GT Resort & Spa

4 to 6 large windmills could generate all of the GTB's net annual electricity needs.

Why Burn Wood? Biomass is:

- Humanity's Oldest Fuel
- Sustainable & Locally Available
- Often a Waste Product
- Can Be Low Cost
- Low In Sulfur, Nitrogen, Mercury and Other Pollutants
- Carbon Dioxide Neutral
- **A Renewable Resource**

GTB Woodlands Are Sustainable

APPENDIX D

Grand Traverse Band's Strategic Energy Plan

Adopted January 26, 2005

Grand Traverse Band of Ottawa and Chippewa Indians
Strategic Energy Plan

GTB Energy Vision

The Tribal Council of the Grand Traverse Band of Ottawa and Chippewa Indians envisions a diverse energy future that includes renewable sources such as wind, solar and biomass sources as well as conventional sources of energy such as electricity and natural gas. This vision emphasizes diversity in order to improve environmental quality while also maximizing economic benefits to the Tribe.

Energy Plan

The GTB Strategic Energy Plan includes three areas of focus or goals and an action plan to meet these goals. The three areas of focus are: Energy Diversity, Environmental Quality and Economic Benefits.

<u>Focus on Energy Diversity</u>
Goal: Increase Diversity of GTB's Energy Sources

GTB's primary energy load centers include: the Grand Traverse Resort and Spa, the Leelanau Sands and Turtle Creek Casinos, and GTB government and Economic Development Corporation buildings. Secondary load centers include GTB Tribal housing.

GTB currently relies primarily on conventional electric and natural gas sources for its energy use, and secondarily on propane for space and water heating in some Tribal housing units.

GTB recognizes that increasing the diversity of its energy sources could provide many benefits, including:

Reducing environmental impacts of conventional sources of energy, such as mercury pollution, through reducing reliance on those sources of energy and pollution.

Reducing energy costs by developing energy efficiency measures in Tribally-owned buildings, as well as developing renewable energy sources such as wind, solar or biomass on Tribally-owned land and providing energy directly to GTB buildings.

Stimulating the Tribal and local economy by providing jobs in the development of new energy sources.

Increasing certainty with regard to energy costs, by reducing reliance on sources that traditionally exhibit volatile price changes, such as natural gas.

Setting an example for both native and non-native communities.

Focus on Environmental Quality

Goal: Reduce Environmental Impacts of GTB's Energy Use

Conventional sources of electrical energy have significant impacts on the quality of the environment. Coal-fired power is currently the largest unregulated industrial source of mercury emissions. Mercury contamination of fish poses significant risks to people who eat fish, but more significantly to native peoples who have traditionally relied upon fish as a main staple. Avoiding or reducing fish consumption has negative cultural effects on native communities. Reducing fish consumption also has health ramifications when other, less beneficial, foods are substituted for fish. Lastly, concerns about mercury contamination that reduce demand for fish have negative economic impacts on Tribal fishing operations.

The burning of fossil fuels has also been determined to be a significant factor in climate change. The effects of climate change on the Great Lakes ecosystem could be dramatic. Falling lake levels and warmer air and water temperatures would have severe negative impacts on fish and wildlife habitat.

Nuclear power also poses significant risks to the environment. From the effects of uranium mining, to the potential for radioactive leaks from power plants, to the creation of waste products that are hazardous for thousands of years, nuclear power poses many risks.

As a steward of the natural environment, GTB recognizes that reducing its demand for conventional sources of electricity also reduces the environmental effects of those sources. Through the exploration of non-conventional sources – such as wind, solar and biomass – GTB plans to quantify the environmental benefits of these non-conventional sources.

Focus on Economic Benefits

Goal: Increase Economic Benefits of Energy Use to GTB

GTB recognizes that in many instances there are economic benefits that coincide with diversifying an energy mix. GTB wishes to maximize the economic benefits of its energy use.

Energy efficiency options are usually the most cost-effective means of reducing demand on conventional energy sources. Investments in energy efficiency reduce energy costs.

Investments in other sources of energy such as wind, solar or biomass, can also reduce energy costs by reducing demand for conventional energy sources. Investing in infrastructure building projects, such as a wind turbine or a biomass power plant, can also provide economic benefits in the form of job creation.

Diversifying its energy mix can also help shield GTB from dramatic fluctuations in natural gas prices.

Action Plan

GTB recognizes that diversifying its energy sources will require thorough study. GTB also recognizes that some reliance on conventional energy sources will continue well into the foreseeable future. However, there are certain steps that can be taken in the near future to move GTB down a path of energy diversification. These steps include:

Renewable Energy Diversification Feasibility Study

Conduct a feasibility study to determine cost effectiveness of maximizing the diversity of energy sources utilized at one or more GTB facilities. An example would be fully exploring the effectiveness of energy efficiency, wind and biomass options – both individually and combined – at reducing conventional energy use at the Grand Traverse Resort and Spa. Because of its proximity, it may also be advisable to include the Turtle Creek Casino in this feasibility study. The feasibility study would include an assessment of the economic benefits to GTB in terms of reduced energy prices and increased job creation and related economic development activity. The study would also include an assessment of environmental benefits accruing from the potential energy diversification options. GTB will explore grant funding to fund this study.

Financing Plan

If the Tribal Council approves the results of the Renewable Energy Diversification Feasibility Study, then the Council would consider directing the completion of a financial plan to implement recommendations of the study.

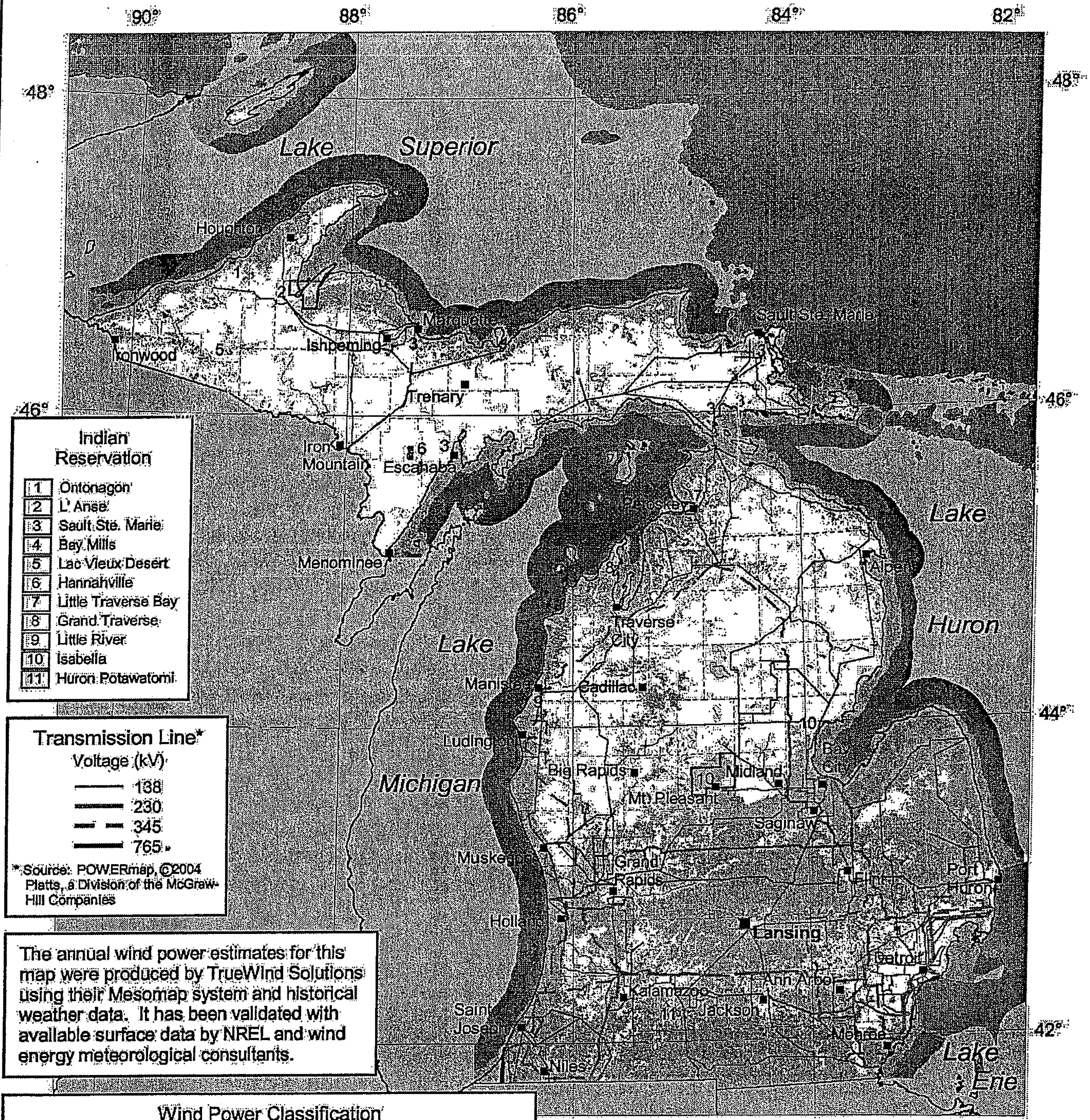
Public Education Campaign

Separate from the activities above, GTB will carry out a public education campaign on the benefits of non-conventional renewable energy resources. This campaign will include articles in GTB's newsletter and other outreach tools such as brochures to be made available at Tribal events. GTB will explore grant funding to implement this campaign.

Distributed Renewable Power Study

Also separate from the activities above, GTB will explore grant funding for a distributed renewable energy plan to augment power to Tribal housing units. An example would be to explore grid-tied net metering of small-scaled wind or solar projects at Tribal housing.

Michigan - 50 m Wind Power



The annual wind power estimates for this map were produced by TrueWind Solutions using their Mesomap system and historical weather data. It has been validated with available surface data by NREL and wind energy meteorological consultants.

Wind Power Classification

Wind Power Class	Resource Potential	Wind Power Density at 50 m W/m^2	Wind Speed[a] at 50 m m/s	Wind Speed[a] at 50 m mph
1	Poor	0 - 200	0.0 - 5.6	0.0 - 12.5
2	Marginal	200 - 300	5.6 - 6.4	12.5 - 14.3
3	Fair	300 - 400	6.4 - 7.0	14.3 - 15.7
4	Good	400 - 500	7.0 - 7.5	15.7 - 16.8
5	Excellent	500 - 600	7.5 - 8.0	16.8 - 17.9
6	Outstanding	600 - 800	8.0 - 8.8	17.9 - 19.7
7	Superb	> 800	> 8.8	> 19.7

[a] Wind speeds are based on a Weibull k of 2.0.

86° 84°

50 0 50 100 150 200 Kilometers

25 0 25 50 75 100 125 Miles

NREL

U.S. Department of Energy
National Renewable Energy Laboratory

30-SEP-2004 3.1.1