# Colville Lake Wind Energy Pre-Feasibility Analysis

Prepared for

# Aurora Research Institute

by

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# Executive Summary

Colville Lake is a community of about 125 people whose electricity requirements are met by a diesel power plant owned and operated by Northwest Territories Power Corporation (NTPC). It is located on the south shore of Colville Lake and is accessible by winter road or by air. The annual mean electrical load is estimated at 39 kilowatts (kW) with a peak at 103 kW and a minimum load of about 20 kW. The diesel fuel cost for energy produced by the plant is $0.43 per kWh at a diesel fuel cost of $1.265 (November 1, 2007) per litre and the plant efficiency is 2.957 kWh per litre. Alternative energy sources would need to be $0.43 per kWh or less to be competitive with diesel energy.

Potential wind energy project sites identified are west and southwest of the hamlet. Where the community borders the lake at 244 metres above sea level (m ASL), there are small rises of land near the community that reach to about 290 m ASL. The wind speed projections for the candidate wind project sites based on the authors' projections using the airport data and the closest upper air stations are significantly below those based on the wind atlas. The authors estimate that the wind speed at 30 m above ground level (AGL) at a plateau that is 800 m southeast of the community is about 4.8 m/s compared to the atlas prediction of over 6 m/s. An accurate assessment of the wind resource would be needed if wind power remains a desire for Colville Lake.

Because of the very small electrical loads at Colville Lake, the authors have looked at relatively small scale turbines, the Bergey 10 kW, and the Wenvor 30 kW, installed in the lowest cost manner possible. Under these conditions a wind project of one 30 kW wind turbine or three 10 kW turbines would yield a medium-high penetration wind-diesel operation, and is estimated to cost about $280,000 to $300,000 ($9,400 to $10,000 per kW). Such projects would generate power at a cost of $1.28 to $1.41 per kWh if the wind resource was 5 m/s. Significant subsidies are required to make a project economically viable, and even a $0.15 per kWh subsidy from the proposed ReCWIP program would provide limited benefit.

If a private individual were to do a project themselves the costs could possibly be reduced to about $7,000 per kW, and would yield power at a cost of about $1.00 per kWh with a 5 m/s wind resource.

Since it appears to be impractical to have a business operate such a small, costly project, the authors suggest that alternative approaches should be considered. One option is mini-hydro which has been considered in the past and may still be a consideration. Another option is the subsidization of home scale wind generators for grid connection in a net metering type of application. A third option would be to consider a grid connected solar power project, in the same arrangement as above or as one large community project. On this scale it might even be practical to have some battery storage. A fourth alternative may be to have NTPC consider battery storage and a cycle charge system in combination with the above. Further work on these options was considered outside the scope of this report.

## Background

JP Pinard, P.Eng. Consulting Engineer and John Maissan, P.Eng. of Leading Edge Projects Inc. (the authors) have been retained by the Aurora Research Institute to conduct a pre-feasibility study for wind energy generation in Colville Lake. This study examines wind data from both the weather balloon (upper-air) and the airport stations and maps and satellite images of the community to identify potential wind monitoring sites. This study provides the following information:

1) Analysis of potential sites for location of wind equipment.
2) Refined estimates of the range of wind speeds around Colville Lake.
3) Size, capacity and condition of present power system in Colville Lake.
4) Analysis of different scenarios of power demands for Colville Lake.
5) Preliminary estimates of the cost of wind generation for Colville Lake.
6) Estimates of power production and gas displacement through integration of wind power.
7) An outline of next steps needed to pursue the integration of wind power in Colville Lake.

## Introduction

Colville Lake is a community of about 125 people, located on the south shore of Colville Lake (Figure 1). The community is situated 750 km northwest of Yellowknife and is at an altitude of 244m above sea level (ASL). Colville Lake is accessible by air and winter road. It is considered to be the most remote in the Mackenzie Valley and also has the most expensive electrical rates of all diesel communities in the NWT.

A diesel-electric generating plant that is owned and operated by the Northwest Territories Power Corporation (NTPC) supplies the electrical energy for Colville Lake. There has been interest expressed in displacing the diesel energy with renewable energy. For example the community now has a solar-powered/diesel hybrid water treatment facility that has apparently been setup to operate from solar-power during the summer.

The purpose of this report is to examine the potential for wind power generation by providing a selection of potential sites, estimating the mean annual wind speed and estimating the economics of building a wind installation near the hamlet.

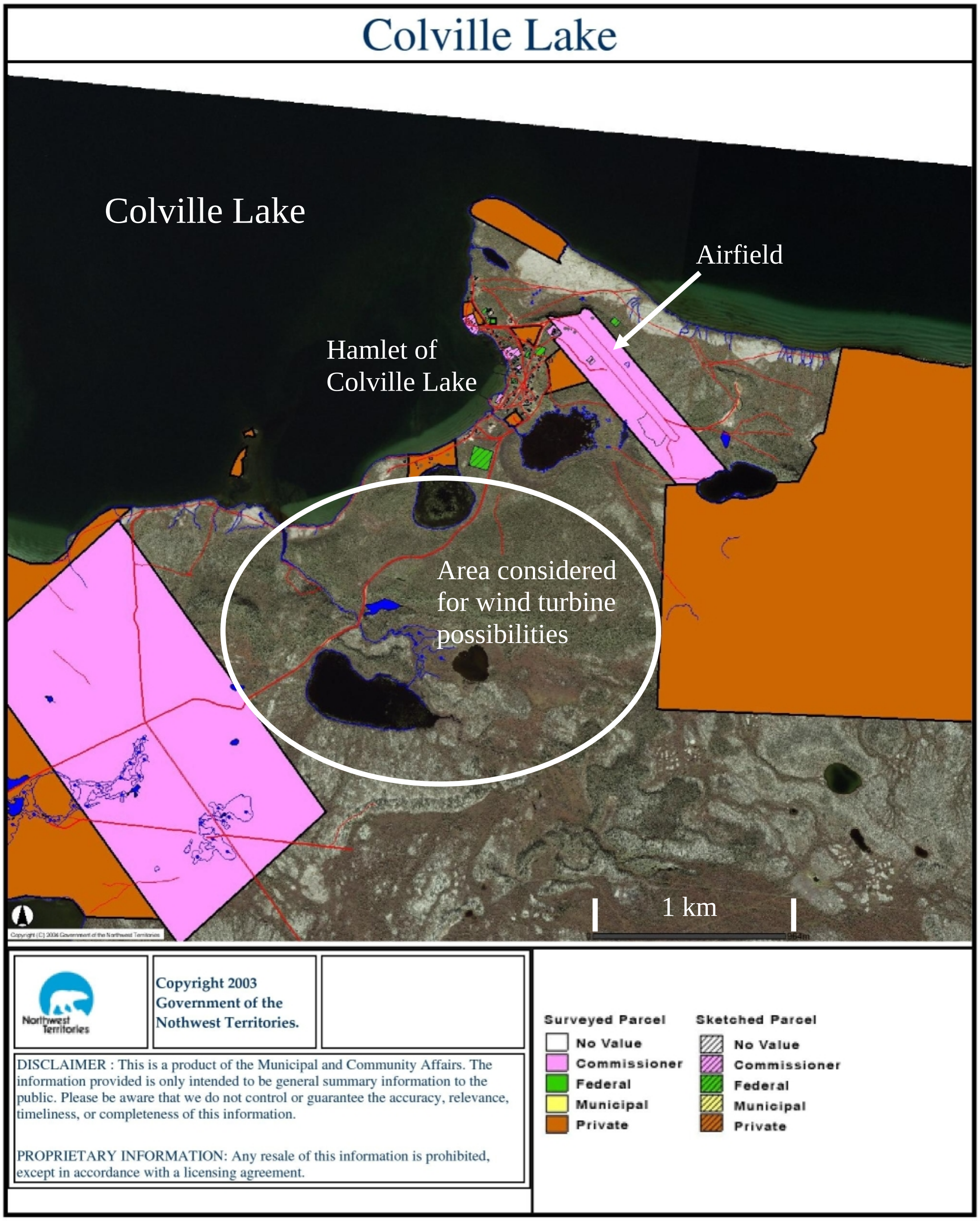


**Figure 1: Map of Colville Lake Hamlet with legal boundaries. Source: Municipal and Community Affairs, Northwest Territories Government.**

## Measured Wind Directions

The wind data used for the wind analysis is extracted from Environment Canada's (EC) climate data which available online at their website (visit their website at www.climate.weatheroffice.ec.gc.ca). The airport station is a 10-m tower located at 259 m above sea level (ASL) next to the airfield. The data contains hourly measurements of wind speed and directions, temperature, pressure, humidity and other fields. About 13% of the wind measurements are missing from the 5-year (2003-07) data set.

Wind turbines are typically placed in a row, preferably on a ridge top, perpendicular to the prevailing wind direction. A wind rose provides an indication of the predominant direction of the wind energy. The wind roses in these studies have two shapes (Figure 2). The solid shaded areas represent the relative wind energy. The wind energy by direction is calculated as the frequency of occurrence of the wind in a given direction sector multiplied by the cube of the mean wind speed in the same direction. There are 16 direction sectors and each sector is 22.5 degrees wide. The given wind energy in each direction is a fraction of the total energy for all directions.

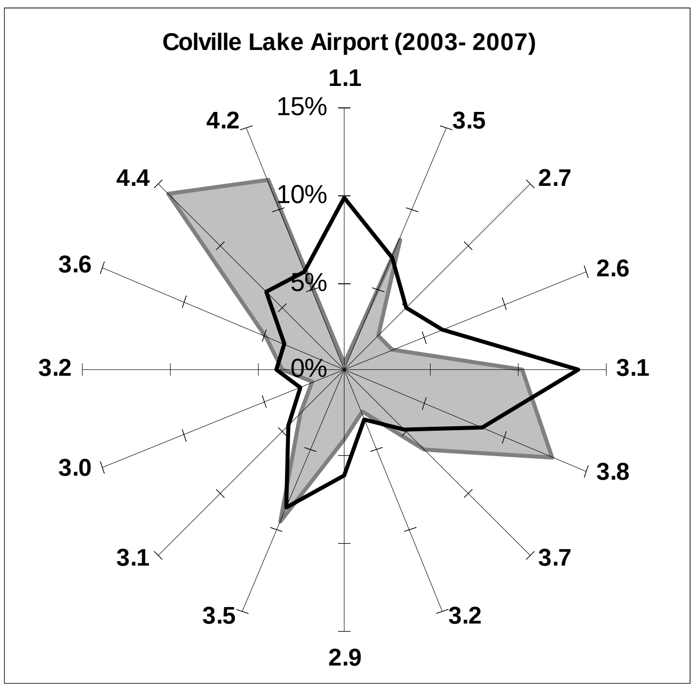


**Figure 2: Wind rose of the Colville Lake airport wind station. The shaded rose which is outlined in grey shows the relative wind energy by direction, and the transparent rose area outlined in black shows the wind frequency of occurrence by direction. The mean wind speed by direction sector is labelled at the end of each axis.**

The transparent area outlined in black is the wind frequency of occurrence by direction as is typically shown in meteorological analyses (Figure 2). The wind frequency by direction can sometimes be misleading, showing a commonly occurring wind direction that is not significant for wind energy production. The outer numbers at the edge of each rose are the average wind speeds in each direction sector.

According to data analysis the wind energy at Colville Lake comes from two dominant directions: about 31% of the energy is from the northwest; and, about 30% is from the east-southeast (Figure 2).

## Suitable sites for wind energy development

When selecting a suitable site for a wind energy development there is a need to consider site elevation, orientation and distance from existing power lines. The wind turbines should have high exposure to the dominant wind directions. In this example a hilltop ridge should ideally be perpendicular to the dominant wind directions and so should be roughly oriented northeast to southwest. Wind turbines could be located along a lakeshore with the open lake upwind (north-northwest) of the farm but with good exposure to the opposite direction as well.

The Hamlet is located on a small peninsula on the south shore of Colville Lake whose elevation is 244 m ASL. The land relief around the Hamlet undulates from the lake elevation to over 280 m ASL. Towards the southeast the land rises gently until it reaches the top of a large hill that peaks at 442 m ASL, 13 km southeast of the community. The mean annual wind speed at this location is likely well above 6 m/s, however, this site too far from the community to consider installing a wind farm economically.

The Hamlet (whose land relief is 245 to 255 m ASL) is located just west of the airfield (260 m ASL) and residences and public buildings are spread along a west-facing bay. The land to the east of the airfield is mostly private land (Figure 1) and does not seem accessible since trails do not appear to go beyond 1 km east of the airfield.

Over one kilometre southwest of the airfield there are several potential wind project sites that have elevations equal to or greater than 260 m ASL (Figure 3). The first location, Site #1 is the closest site to the Hamlet – being 300 m away from the nearest power line. At 260 m ASL, it is essentially the same elevation as the airport. From the community's official land use plan there are intentions for a new housing area near this site, which will likely bring the power line about 150 m closer to this site. However this means that the wind turbines will be within 200 m to residences, this may encounter resistance from the community. Site #2, is at 268 m ASL, is 150 m from the winter road and about 750 m from the power line. Assuming that a new housing area will be developed at the southwest end of the community this site may be about 600 m from the southwest end of a future extended line.

To the east of Site #2 the land drops and then gently rises again to a plateau of that peaks at 280 m ASL, 1.3 km away. Site #3 is on the northern edge of this fairly wide, flat area and has potentially ample room for many wind turbines. This site is about 800 m from the power line in the community. It is however 1 km south-southwest of the centre of the airfield and at a minimum, lighting may be required on the towers.

There is a fourth site, #4, being at 288 m ASL may have significant wind energy potential, but it is at least 1.3 km away (Figure 3) from the existing power line.

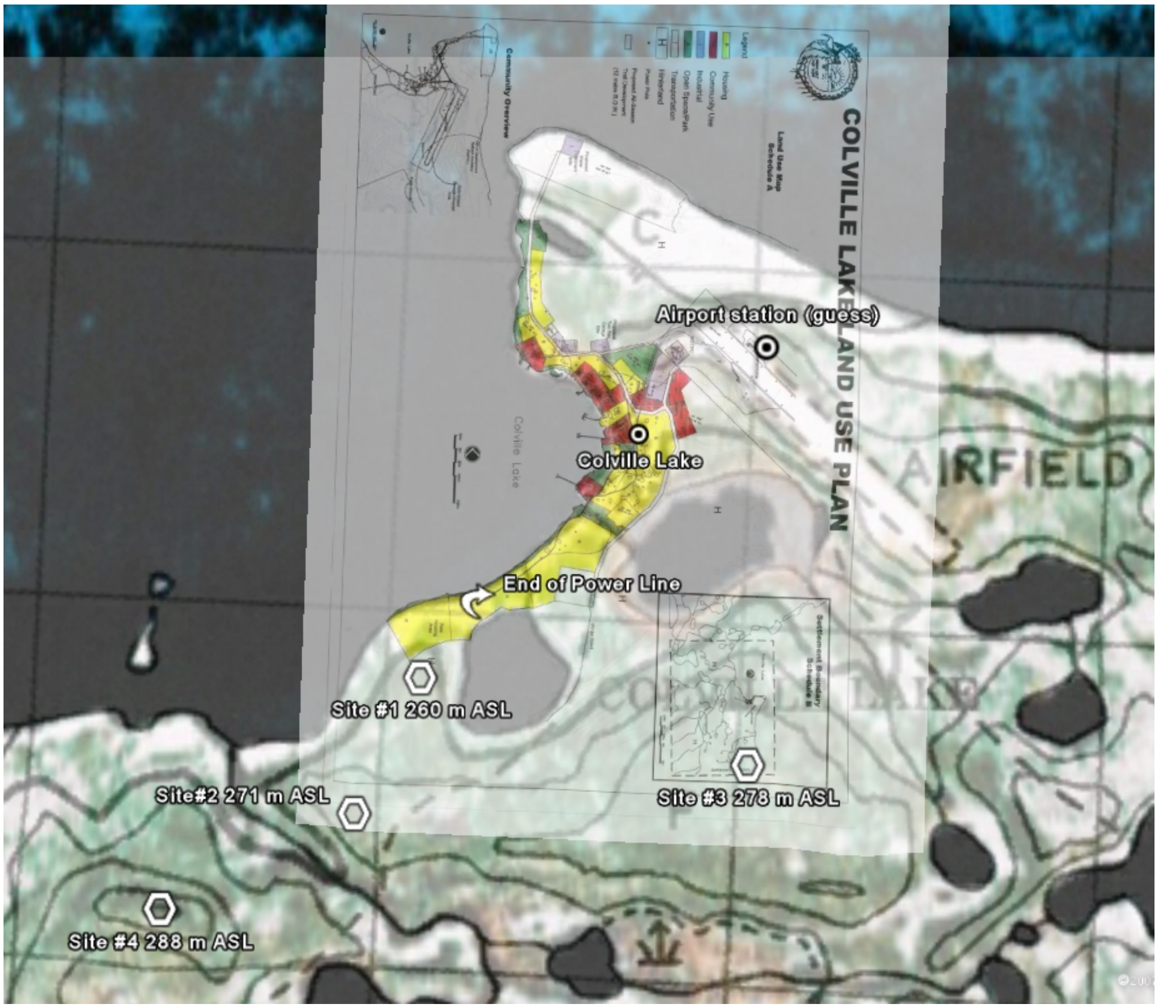


**Figure 3: Map of Colville Lake overlain by a map of the community land use plan and the airfield. The contour interval is 10 m, the lake is 244 m ASL. The grid squares are 1 km wide.**

## Measured and Projected Wind speeds

The long term mean annual wind speeds at the potential wind installation sites around Colville Lake can be estimated using measurements from the airport and the nearest upper-air stations (Table 1). Over a five-year period (2003-2007) the annual mean wind speed measured at the Colville Lake airport was 3.14 m/s. This measurement was made at 10 m above ground level (AGL) which is 259 m above sea level (ASL).

**Table 1: The upper-air stations used in wind speed projections**

| Upper-air Site | Location relative to Colville Lake | Elevation | 10-yr mean Wind speed at 10 m AGL |
|---|---|---|---|
| Inuvik | 350 km WNW | 103 m ASL | 2.8 m/s |
| Norman Wells | 180 km S | 95 m ASL | 2.4 m/s |
| Fort Smith | 1050 km SE | 203 m ASL | 2.2 m/s |

The wind speed measurements from upper-air stations provide vertical profiles of mean horizontal wind speeds that can be used as a guide to estimate the local winds at higher altitudes above Colville Lake. In observing the profiles for the three upper-air stations in the NWT it becomes clear that there are similarities in wind speed at certain elevations AGL (Figure 4) [1]. At 200 m AGL for example, the mean wind speeds at all three stations are approximately 6.2 m/s. Included in Figure 4 is a fourth profile (labelled Colville Lake log) that represents the estimated logarithmic profile for the Colville Lake site based on its 10 m annual mean wind speed of 3.14 m/s.

The (natural) logarithmic law profile uses the equation:

$$U_2 = U_1 \frac{\ln\left( z_2 / z_o \right)}{\ln\left( z_1 / z_o \right)}$$

where $U_1$ is the airport wind speed at height $z_1$ = 10 m AGL and $U_2$ is the projected wind speed at a higher elevation of $z_2$ m AGL. The length $z_o$ = 0.5 m represents the surface roughness of the area around the wind station. The surface roughness is adjusted so that the logarithmic profile intersects through the average wind speed of 3.14 m/s at 10 m AGL and 6.2 m/s at 200 m AGL. The logarithmic profile more closely matches the Fort Smith measurements at 100 and 200 m AGL. Fort Smith and Colville Lake are more similar to each other than to the other sites because they are at similar elevations ASL and they are more centrally located within the continent.

The fifth profile included (Figure 4) is the wind speed projections based on the Hellman's exponential law:

$$v_w(h) = v_{10} \bullet \left( \frac{h}{h_{10}} \right)^a$$

where $v_w(h)$ [m/s] is the velocity of the wind at height, $h$, $v_{10}$ [m/s] is the velocity of the wind at height, $h_{10}$ = 10 meters (or other reference point height); and $a$ is the Hellman exponent. The Hellman exponent is normally about 0.15 for relatively open areas,

[1] Note that at Norman Wells and Inuvik the balloon measurements are made at the surface and 200 m AGL and the wind speed is interpolated between those two heights. The wind speeds between these two elevations are underestimated. At Fort Smith measurements are made between surface and 100 m AGL. The estimate of ten-year mean wind speed at 100 m AGL is considered more accurate above Fort Smith than over Inuvik and Norman Wells.

however in these calculations it was set to 0.23 is achieve the nearest match with the Fort Smith profile. The profile based on Hellman's equation yields lower wind speed projections above the reference points than does the logarithmic equation with the calculated roughness coefficient of 0.5 m. The (natural) logarithmic law is generally used in scientific circles and there is a higher confidence level in this law than in Hellman's exponential law, but both are used in the wind resource assessment industry.

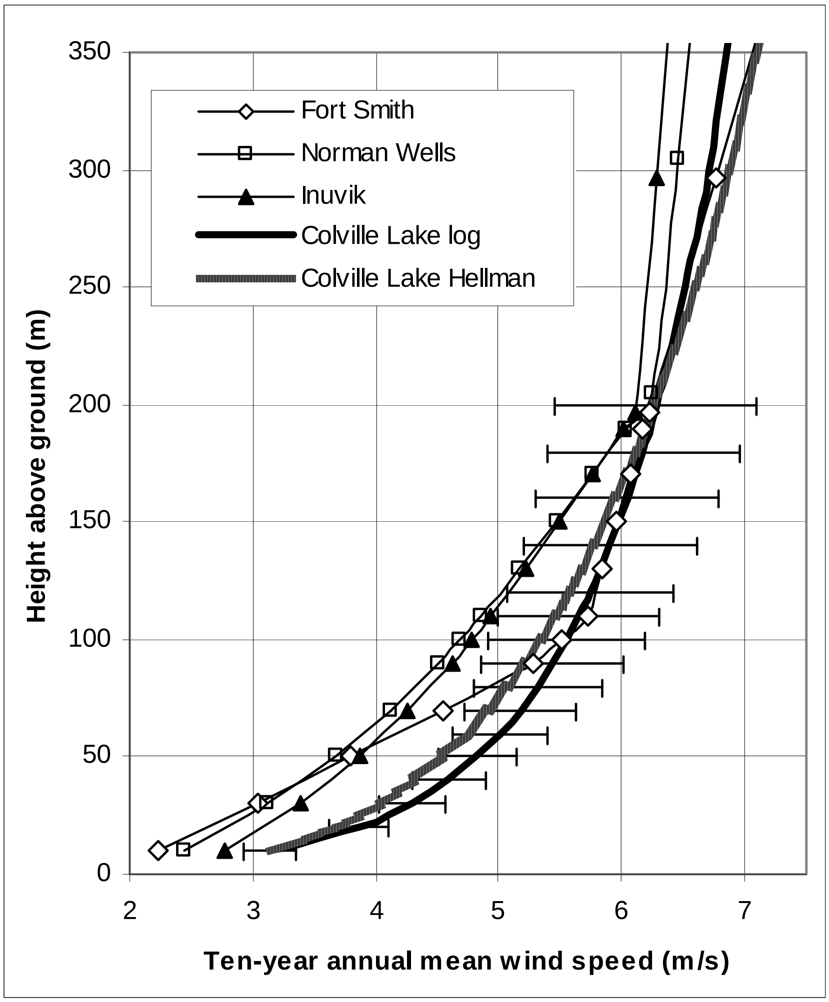


**Figure 4: Profiles of the ten-year annual mean wind speed for three upper-air stations listed in Table 1. The error associated with the logarithmic law speed wind profile is the standard deviation of the annual mean wind speed over the 10-year period.**

The ground level at the airport wind station at Colville Lake is 259 m ASL. There is an elevation gain ranging from 0 to 29 m between the airport and the sites identified. All of the elevation gains of the sites along with the projected wind speeds are shown (Table 2).

The logarithmic profile in Figure 4 above indicate that the average annual wind speed at 30 and 60 meters AGL at the Colville Lake airport would be 4.29 m/s and 5.02 m/s respectively. At 50 m AGL the standard deviation on the annual wind speed is about ± 0.39 m/s thus the annual mean wind speed could vary from 4.63 m/s to 5.41 m/s. The wind speeds at 30 m AGL for the identified hill top sites (#1 to #4) were estimated to be in the range of 4.29 to 5.02 m/s (Table 2). Values were estimated at 30m AGL because, as will be discussed later, this is the standard tower height of the wind turbines that are appropriate for this community.

**Table 2: A list of sites showing their elevations, and estimated 10-year mean wind speed. This also includes the relative elevation of the site above the airport and the spacing available at the site for wind turbines. The variation associated with the speed wind is the standard deviation of the annual mean wind speed over the 10-year period (also shown as error in Figure 4).**

| Wind site | Site height ASL | Height above airport | Distance from power line | Approximate space available | Annual mean wind speed at 30 m AGL |
|---|---|---|---|---|---|
| Site #1 | 260 m | 0 m | 300 m | 25 by 50 m | 4.29 ± 0.27 m/s |
| Site #2 | 271 m | 12 m | 750 m | 40 by 60 m | 4.59 ± 0.29 m/s |
| Site #3 | 278 m | 19 m | 800 m | 100 by 100 m | 4.83 ± 0.32 m/s |
| Site #4 | 288 m | 29 m | 1300 m | 20 by 100 m | 5.02 ± 0.39 m/s |

The five-year mean monthly wind speed at the airport (10 m AGL) is shown along with estimates for the four potential wind turbine sites using a hypothetical tower at 30 m AGL. (Figure 5) The monthly mean wind speeds (measured at 10 m AGL) at the airport reach a maximum 3.6 m/s in September and October and reduce to a minimum 1.7 m/s in January under the influence of winter inversions. At Site #1, for a 30 m tower the estimated mean monthly wind speed should reach a maximum of 5.0 m/s in September and minimum of 2.3 m/s in January. The other sites are higher and the wind estimates for these sites are proportionately greater, however they are further away from the power line.

The Canadian Wind Atlas has been used to identify areas of high wind energy potential but is of limited use in northern Canada because it uses large scale models to estimate wind speeds at a given location within the country and the wind data available for the north is relatively sparse. The grid resolution of the model is 5 km by 5 km and wind speed and energy information is available at each of these grid points. According to the Wind Atlas the nearest grid point to Colville Lake (Colville Lake is at 67.038N and 126.092W) is at 66.988N and 126.174W. At this grid point the simulated long term mean wind speed is 6.01 m/s, and 6.30 m/s at 30 m, and 50 m AGL respectively. The wind speed at 50 m AGL is substantially greater than the wind speed of 4.83 m/s estimated in this report. Given these significant variations in wind speed estimates from different methodologies, preparing more accurate estimates of the wind resource from an onsite wind monitoring station would be important if serious consideration is to be given to the development of wind power. Adequately high wind speeds will be critical to the economics of a project.

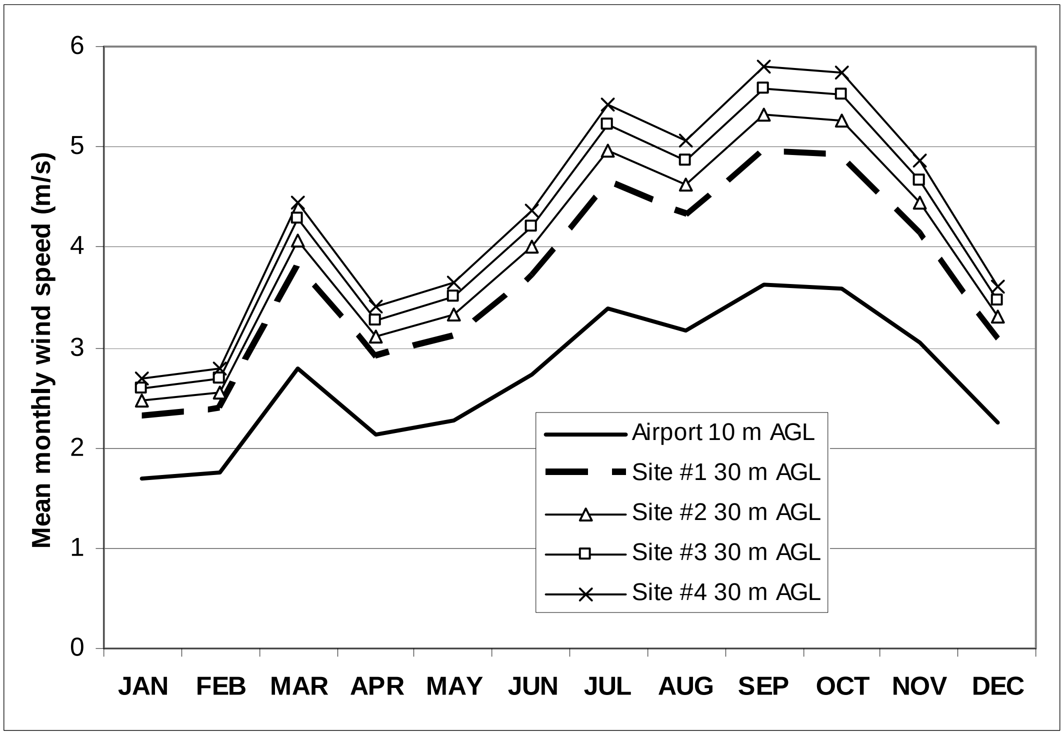


**Figure 5: Estimated mean monthly mean wind speed at the four elevations comparable to the 30-m hub height for wind turbine at the identified nearby sites. These are compared to the 2003-2007 mean monthly wind speeds measured at the airport.**

The Colville Lake airport wind speeds should not be used in isolation of other information for projecting wind speeds at higher elevations. Results from the Community Wind Resource Assessment Program in Yukon show that when wind speed measurements at 10 m AGL are used in isolation to project wind speeds at higher elevations they typically underestimated the wind resource.

Two additional considerations for wind speeds around Colville Lake include: i) it is possible that there is an enhancement of the wind resource on the hill tops due to speed-up effect of wind flowing over them and ii) there is an increased risk of rime icing effects on these hilltops and there is high cost of roads and power lines to access these sites.

## Power requirements and costs

Power demand and energy forecasts for 2006 to 2008 prepared by the NTPC for a late 2006 rate application indicate a peak demand of 103 kW and an annual energy requirement of 339,000 kWh for 2007-2008. The average annual energy indicates an average electrical demand of 39 kW, and the authors would further estimate that the minimum demand would be in the order of 20 kW. Relevant NTPC rate application information is contained in Appendix 1. The diesel plant contains three generators, two are rated at 75 kW (Detroit Diesel model #4-71), and the third is 90 kW (Isuzu A6GB1T).

Also according to NTPC rate filings the forecast fuel efficiency for the diesel plant is about 2.957 kWh per litre (for 2007-2008), and the fuel cost was $1.265 per litre on November 1, 2007 at the time NTPC prepared their wind generation RFP (see Appendix 2). The incremental cost of electrical energy is $0.43 per kWh; this is the price that NTPC would pay for electricity from an independent power producer such as a wind farm owner.

Appendix 3 provides a table of the value of diesel fuel savings as a function of diesel fuel cost using the plant's efficiency of 3.0 kWh per litre (rounded up from 2.957). As can be seen from this table a fuel cost of $1.25 to $1.50 per litre results in per kWh costs of $0.417 to $0.500 per kWh. In addition to the fuel there may be a small amount of other variable costs that are displaced when diesel generation is avoided. The savings that would be attributable to wind generation are thus substantially below the retail cost of electricity which is between $2.50 and $3.00 per kWh on the margin for residential consumers. Retail electricity rates contain cost components related to distribution and generation capital costs, distribution and generation maintenance costs, distribution and generation losses, billing system and other administrative and overhead costs. These costs will not be reduced by wind power generation.

# Wind power project

Wind turbines

The average electrical load of 39 kW and a minimum of 20 kW suggest that the usual community size wind turbines of 60 to 100 kW are too large for Colville Lake. The authors considered that the use of one 30 kW three phase Wenvor wind turbine or three single phase Bergey EXCEL-S 10 kW units in this community would be appropriate as that would be the most that could be installed as a medium-high penetration project. A community scale wind turbine (i.e. 60 to 100 kW) would result in a high penetration wind-diesel system with all its complexities, a significant amount of surplus wind energy, and with a significant capital cost. The Wenvor turbine is Canadian made and has been developed over the past 5 to 10 years, so has limited track record and none are installed north of 60. The Bergey EXCEL-S 10 kW unit (or predecessors) has been in the market place for over 30 years and has been used the world over. It is rated for operation in temperatures down to -40°C.

Energy Production

Both the Bergey and the Wenvor turbines exhibit limited power production in low wind speeds. They have power curves that are more suited to high wind speed regimes. This is in contrast to the Northwind 100 (a 100 kW turbine with a rather large 21 meter rotor, suited for larger community loads) which has a relative power output substantially higher at low wind speeds.  The energy produced by three Bergey EXCEL-S 10 kW wind turbines is detailed in Appendix 4.

At an average annual wind speed of 5.0 m/s (optimistic for the realistic installation sites) the amount of useful energy that would be produced from three Bergey units is 22,572 kWh per year.  This represents a penetration level of just over 6.6% if it all displaced diesel energy but we know that the installed capacity would exceed the minimum diesel plant load, so some will be surplus.

Capital costs

Capital cost estimates were gathered for two possible project options: one with three Bergey 10 kW turbines and a second with one 30 kW Wenvor turbine. Both of these projects would be considered medium-high penetration wind diesel projects. These two wind-diesel projects were examined because there are few other turbines available in the 5 kW to 30 kW range.  This study did not consider a single community scale (60 to 100 kW) turbine as this would result in a high penetration wind diesel system with its additional complexities in wind-diesel integration and higher capital costs. Power lines are very expensive to build in Colville Lake, probably in excess of $200,000 per kilometre. Thus the authors minimized the estimated capital costs, particularly with the power line, by assuming that the turbines would be installed within the confines of the community where there are suitable power lines nearby.  All costs not associated with the purchase of the equipment were also estimated as low as could be justified.  An alternative to spending money on power lines would be to spend it on custom designed taller towers.  There may be a downside of increased airport concerns.

Appendix 5 details the capital cost estimates.  The cost for a single 30 kW Wenvor turbine project was estimated to be $282,000, whereas the three Bergey turbine project was estimated to cost $298,000.  These figures represent per kW costs of about $9,400 to $10,000 per kW of installed capacity.

Annual Costs

The annual costs of wind projects as a function of the capital costs (at 8%, 6%, and 4% cost of capital spread mortgage style over 20 years) and a range of operating costs are presented in Appendix 6.  Even at 4% effective interest rate the annual mortgage style payments for the projected capital costs would be about $20,000 to $22,000 per year. Operating costs of $1,000, $2,000, and $3,000 per year for a 30 kW project were considered.  This is likely to be a bit optimistic.

Cost of wind energy, economic analyses and discussion

A matrix of capital costs (at 8%, 6% and 4% interest rates), operating costs (three levels), and a range of wind speeds was then constructed to yield the cost of the wind energy produced.  The results show that the cost of wind energy from a 30 kW wind project at the expected capital and operating costs with a wind speed of 5.0 m/s is $1.28 to $1.41 per kWh before subsidies (8% interest).  This is not even close to the cost of diesel power at 0.43 per kWh that would be provided as revenue for the wind energy produced.  If the wind speed were 6 m/s rather than 5 m/s, the cost of energy would still be $0.76 to $0.84 per kWh. The power cost tables are presented in Appendix 7.

To be economic very substantial capital and / or operating subsidies would need to be provided. Other alternative project approaches or other alternative energies should be considered given the projected high cost of wind energy. Four alternatives are suggested by the authors for consideration and discussion, but it was considered beyond the scope of this report to examine them in more detail.

First is consideration for a mini hydro project that could displace all of the diesel power. Total diesel displacement would result in a saving of $145,770 per year in fuel. If $125,000 per annum of this were available to repay capital at 8% cost of capital (mortgage style), the justifiable capital cost would be $1.44 million. Given that with a mini hydro plant carrying the entire load there would also be maintenance and capital cost savings for NTPC, the revenue would be higher and the justifiable capital cost higher. Furthermore, any surplus hydro could go to offset oil heating costs. Heat energy would have a value of about $0.13 per kWh (at $1.265 per litre), but it would at least be some additional revenue.

A second alternative would be to provide rebates to individual customers to allow them to put up small individual turbines designed for low wind speeds. Some examples of turbines that could be considered include the Southwest Windpower Skystream 3.7 with an output of up to 2.6 kW, or the Southwest Windpower Whisper 200 of about 2 kW peak output. Residents could then put the turbines up themselves in grid connect / net metering fashion (or perhaps on the NTPC side of the meter) and avoid all the cost that businesses would need to incur. Some issues would need to be resolved with NTPC, as well as with Transport Canada, and Nav Canada (towers) on a community wide basis before this approach could proceed.

A third alternative would be to subsidize PV systems to be installed on the roofs of homes and buildings, and connect them to the grid in the net metering fashion described above for wind. An advantage of solar PV is that it is very low maintenance compared to wind generators, they make no noise, and there are no towers involved (no bird issues and no Transport Canada or Nav Canada issues). Given the expected cost of wind power ($1.28 to $1.41 per kWh) solar PV is likely to be cheaper and much easier. PV arrays could be permanently mounted for the optimum solar power generation (vertical facing south).

A fourth and final alternative would be for NTPC to consider battery storage and a cycle charge system to improve fuel efficiency, perhaps in combination with the small wind or PV alternatives discussed above. With this approach when the electrical load is low the surplus power produced at windy or sunny times would be stored, then recovered through an inverter at times when the load is higher and or the alternative energy in short supply. This option does introduce complexity and may not be attractive for that reason.

## GHG Reductions

For the purposes of this report it has been assumed that all of the electrical energy available to reduce diesel generation does in fact reduce diesel generation. While it may a bit optimistic it is a reasonable first approximation.

The diesel fuel and GHG reductions that would be achieved by a 30 kW project at various annual average wind speeds are shown (Table 3). The calculations are based on a diesel plant efficiency of 3.0 kWh per litre, and GHG emissions of 2.83 kg $CO_2$ (based on GNWT's figure for non-motive diesel) equivalent per litre of diesel fuel consumed.

**Table 3 Annual GHG reductions from a 30 kW wind project by wind speed**

| Wind speed, m/s | Diesel electricity displaced, kWh | Diesel fuel saved, litres | GHG reductions, kg $CO_2$ equivalent |
|---|---|---|---|
| 4.50 | 16,313 | 5,438 | 15,390 |
| 5.00 | 22,572 | 7,524 | 21,293 |
| 5.50 | 29,985 | 9,995 | 28,286 |
| 6.00 | 37,962 | 12,645 | 35,785 |
| 6.50 | 46,170 | 15,390 | 43,554 |

## Conclusions

1. The highest hill in the area of Colville Lake that could provide over 6 m/s annual mean wind speed (desired for an economic wind project) is 13 km away and too far for consideration. The wind speed at the airport at 10 m AGL is only 3.14 m/s annual average and at 30 m AGL would be projected to be about 4.29 m/s. Nearby sites that could have wind project potential are up to 30 metres higher in elevation than the airport and have projected wind speeds of up to 5 m/s annual average. Many of these sites are too far from power lines to be economic.
2. Colville Lake has an average electrical load of only 39 kW and a minimum load in the order of 20 kW, very small indeed. The most appropriate size of wind power project is 30 kW, which would likely cost $280,000 to $300,000 ($9,400 to $10,000 per kW) or more to construct, estimated on the low side, and on an unsubsidized basis would produce power at a cost of $1.28 to $1.41 per kWh with a wind speed of 5 m/s. Very significant subsidies would be required for wind power to be economic. The purchase of the turbines and towers, and their transportation to the site would be well over half of the total capital cost.
3. The only logical sites for wind development to avoid the high cost of power lines (probably in excess of $200,000 per km) are the highest sites directly adjacent to the community's existing power lines. Rather than incur power line costs it may be more practical to consider custom designed taller towers.

4. Given these high costs it is recommended that a different approach to wind energy could be considered. Individual household turbines could be owned, installed, operated, and maintained by residents for the utmost simplicity.
5. There is a significant discrepancy between the projected wind speeds as calculated by the authors and the Canadian Wind Atlas figures. This discrepancy could only be resolved by the installation of a wind monitoring station near the community. However, given the very poor economics of wind energy based on the airport measurements, it may be wise to put that money towards subsidizing another alternative energy approach.
6. It is also recommended that other alternative energies be examined, including the mini hydro and solar PV. Solar PV is easy to install, requires very little maintenance, involves no moving parts or towers, and can be installed on existing buildings. It is likely to be no more costly than wind energy and may be less costly if the equipment is purchased in bulk.
7. Green house gas reductions in the order of 21,293 kg per year would be achieved with a wind project of 30 kW and a wind resource of 5 m/s.

## Next steps

Careful and critical consideration needs to be given to all of the information in this report with regard to developing a wind power project in Colville Lake. It is recommended that the following be considered as next steps.

1. Given the projected high cost of wind energy, other alternative energy approaches should be considered prior to proceeding with a wind monitoring station. Wind monitoring stations can be quite costly and the costs could be allocated to subsidies for another alternative energy approach.
2. If it is desired to consider wind energy seriously, a wind monitoring tower should be installed at a location near the existing grid where a wind turbine could be installed. A tower of 30 meters would probably serve the intended purpose but a taller tower would provide more information transferable to locations outside the community.
3. If it is desired to promote wind energy all things having been considered, it can be done most practically by encouraging individual citizen installation and ownership at their homes and businesses.