Progress Report for Thor Lake Wind Monitoring 2009-2010

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Summary

One year of wind data was analysed from a 50 m meteorological station installed near Thor Lake on a ridge overlooking the Hearne Channel. The projected long-term (10 years) average wind speed at 48 m above the ground is estimate to be 5.74 m/s. At 80 m above ground, the long-term wind speed is estimated to be 6.5 m/s.

The GE 1.5sle wind turbine with an 80 m tower was used for this preliminary analysis. This commonly used 1.5 MW turbine is estimated to produce 3.06 GWh/year based on a 6.5 m/s wind speed average. This model of turbine is estimated to cost $6.75M to install, or $4.5M per MW. This wind plant will cost about $0.28 for each kWh of wind energy production. This is comparable to the cost of diesel-generated electricity at the future mine site, which was estimated at $0.29 per kWh.

An optimum size wind park of four turbines with total a capacity of 6 MW could be installed at the mine and this would reduce the production cost to $0.25 per kWh. This wind park would cost $22.3M or $3,700 per kW of installed capacity. The capital cost can be reduced if the project is built simultaneously with the mine. Subsidies may soon be available from the federal government through a Northern Wind Incentive Program (NorWIP). If this program is available then there could a cost saving of $0.06 per kWh bringing the cost of a wind project at Thor Lake down to about $0.19 per kWh.

Introduction

Following the initial request from Avalon and a desktop study (Pinard 2009) that suggested that the wind potential in the Thor Lake was likely to be very good, a wind monitoring program was initiated for this mine site. The Thor Lake meteorological (or "met") station was erected on September 17th, 2009 and one year of data has been gathered for this study to date.

The tower is located on high ground next to the Hearne Channel and is shown in Figures 1 and 2. Its elevation is about 250 m above sea level (ASL) and it is 90 m above the channel and about 500 m north of the shoreline. The tower is 50 m tall and is equipped with wind sensors at 20 (speed and direction), 30 (speed), 40 (two speed sensors), and 48 m above the ground (two speed and one direction). The station also has a temperature sensor at 2 m above the ground.

In this pre-feasibility, study the wind data will be analysed and projected to long-term values using the nearby Inner Whalebacks weather station. The wind speed data, adjusted to long-term, will then be used to calculate the wind energy production of a select popular wind turbine: the GE 1.5sle, a 1.5 MW (megawatt) wind turbine with a 65 and an 80 m tower option. This wind turbine was used for a case study for wind energy potential in Yellowknife (Pinard and Maissan 2008) and three were installed in 2009 on Kodiak Island in Alaska. The wind energy production cost will then be calculated based on the useful wind energy output and the estimated capital and operation and maintenance cost for such a turbine. Also included in this report are the anticipated greenhouse gas savings that will be made by the wind plant, and a discussion of funding sources that are available for developing wind energy at this site.

Figure 1: View looking east of the met station at Site #1 (see Figure 2) by the Hearne Channel.

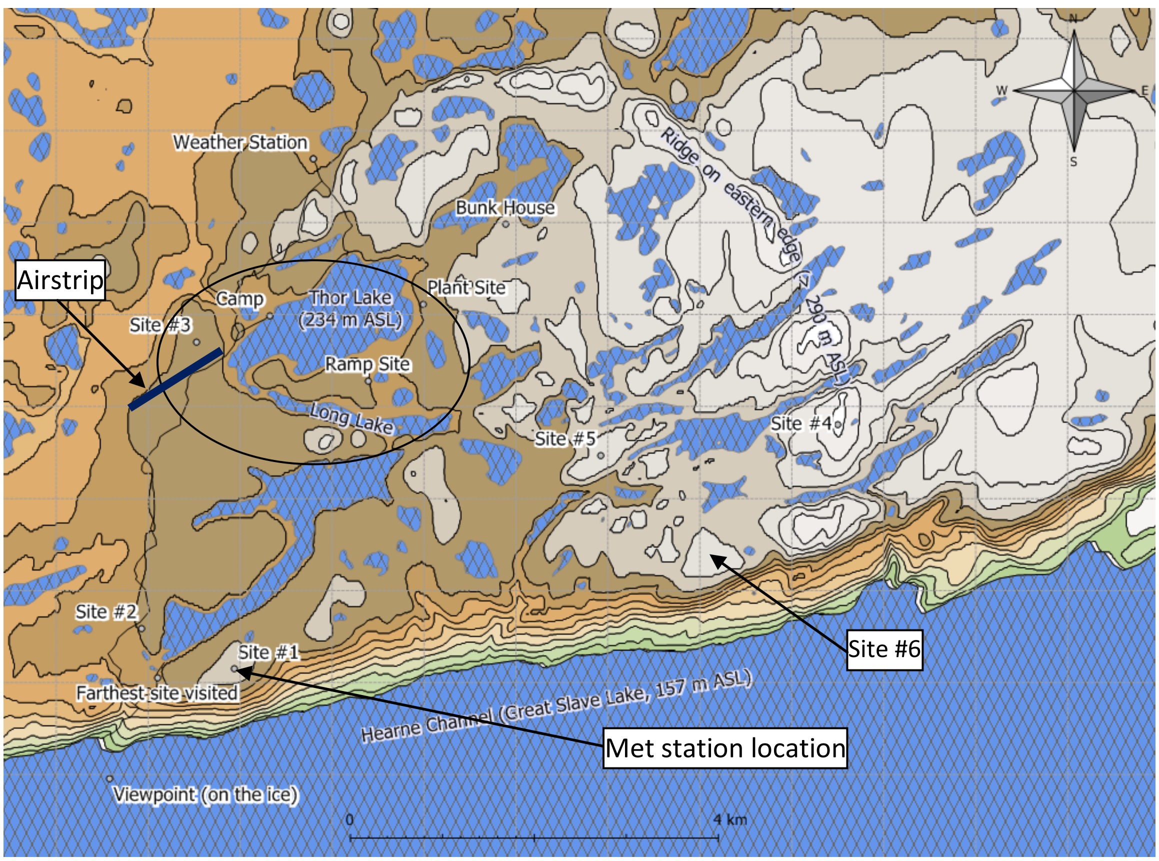

Figure 2: Topography of the Thor Lake area showing the proposed locations of the mine (oval). The contours depict 10 m intervals starting at 160 m above sea level (ASL) at the Hearne Channel shoreline (the channel is at 157 m ASL). The contours reach a maximum height of 290 m ASL towards the ridge to the east.

Wind Data Analysis

For this study, the Thor Lake met station data was correlated to the Inner Whalebacks Environment Canada weather station (about 60 km west of Thor Lake) for the period of September 17, 2009 to September 23, 2010. During that time, the average wind speeds at the Thor Lake met station were 4.93 and 5.67 m/s at 30 and 48 m above ground level (AGL), respectively; and, at the Inner Whalebacks station they were 6.41 m/s at 10 m AGL.

The short-term wind speed measured at the Thor Lake met station site was adjusted to a ten-year mean using the MCP (Measure-Correlate-Predict) method to estimate the long-term mean winds. The formula is:

$$E_s = \mu_s + \frac{R \cdot \sigma_s}{\sigma_r}(E_r - \mu_r)$$

where E_s is the estimated long-term wind speed at the site of the wind monitoring station, μ_s is the measured wind speed at the site (Thor Lake), μ_r is the measured reference wind speed (at Inner Whalebacks), and E_r is the measured long-term mean wind speed at the reference station. The other variables in the equation are the correlation coefficient (R), the standard deviations for the reference station (σ_r) and the wind monitoring site (σ_s). These values are listed in Table 1.

The correlation between the Thor Lake met station and the Inner Whalebacks station data during that period is R = 0.55, which is considered to be a fair correlation (R = 1.0 is perfect, 0.0 means no correlation). The long-term mean wind speed (10 years from Oct 2000 - Sept 2010, represented by E_r) at the Inner Whalebacks station is 6.54 m/s. From the above formulae, the ten-year (2000-2010) projected mean of the Thor Lake Wind site (E_s) is 5.72 m/s at 48 m AGL.

Table 1: Details of values in the evaluation of the long-term mean wind speed of the Thor Lake met station using the Measure-Correlate-Predict method.

Measure-Correlate-Predict	Values	Units	Height AGL
Estimated Long-term mean at site E_s =	**5.72**	m/s	48 m
Estimated Long-term mean at reference E_r =	6.54	m/s	10 m
Measured site u_s =	5.67	m/s	48 m
Measured reference u_r =	6.41	m/s	10 m
Measured cross-correlation coefficient R =	0.55		
Measured standard deviation at site σ_s =	2.48	m/s	48 m
Measured standard deviation at reference σ_r =	2.99	m/s	10 m

Table 2 shows summary values of wind speeds for the Inner Whalebacks and Thor Lake met stations. The Thor Lake met station numbers include wind projected to higher levels above ground. These numbers were obtained by using logarithmic law formulation.

Turbulent air flow over rough surfaces tends to generate a vertical profile of horizontal winds that are fairly predictable. The wind speed profile near the ground is dependent on neutral well-mixed air conditions and the roughness of the ground surface. This vertical profile can be defined by the natural log law equation:

$$u_2 = u_1 \frac{\ln(z_2/z_o)}{\ln(z_1/z_o)}$$

where u_1 is the known wind speed at z_1 (typically at 10 m AGL), and is projected to u_2 at the height z_2. The surface roughness is defined by z_o which as a rule of thumb is 1/10 the height of the grass, brush, or ground undulations surrounding the site where the measurements are made. This equation is considered most accurate up to approximately 100 m above the surface. The surface roughness z_o can be categorised by the type and size of vegetation as well as the hilliness of the ground itself. If we know the wind speeds at two heights (e.g. 10 and 30 m), then we can also find the value of z_o, look the value up on a roughness chart and compare the land description to the actual ground surrounding the station. With the known z_o we can use the log equation to predict the wind speed at higher elevations.

The surface roughness based on the measurements made at the Thor Lake met station site is calculated to be z_o = 0.9 m, this would represent a surface roughness of forested area with rough terrain.

Table 2: Details of measurements and their projections to longer term and to higher elevations. The Thor Lake data is correlated to the Inner Whalebacks (IW) weather station, about 60 km west of the site. Bold values indicate the estimated long-term (10 years, 2000-2010) mean wind speed at the Thor Lake met station.

Location and measurement period	Height (mAGL)	Wind speed (m/s)
Inner Whalebacks Sept 2009 to Sept 2010:	10	6.41
Thor Met Stn Sept 2009 to Sept 2010:	20	4.37
	30	4.93
	40	5.38
	48	5.67
Inner Whalebacks 10-year (2000-2010) mean:	10	6.54
Ratio of 2009-2010 to 10-year mean at IW stn:		1.02
Thor met site projected to 10 years:	10	**3.47**
	20	**4.46**
	30	**5.05**
	40	**5.46**
	48	**5.72**
	50	**5.78**
	60	**6.04**
	70	**6.27**
	80	**6.46**
	90	**6.63**
	100	**6.78**

At the site of the Thor Lake met station (Site #1) the mean long-term wind speed at 80 m AGL is estimated, according to the best fit of the log law curve, to be 6.46 m/s. A graphical representation is given in Figure 3.

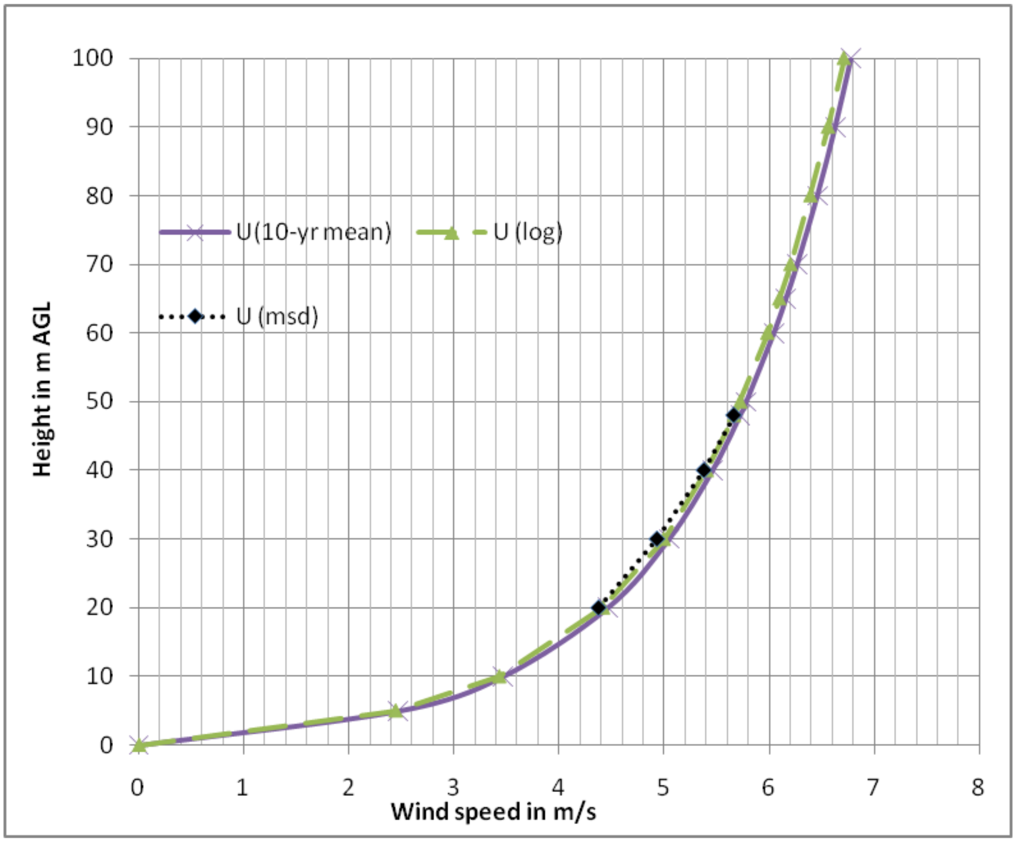

Figure 3: Vertical profiles of horizontal wind speeds at the Thor Lake met station. The vertical profile "U(log)" is fitted to the measurements "U(msd)" and then adjusted to the long-term profile "U(10-yr mean)".

To assist in designing the layout of a wind farm at Thor Lake, the wind energy rose in Figure 4 shows that there is one important wind direction to pay attention to. Because the winds are mostly from the east, a wind turbine should be placed on a hill that is well exposed to the east, and which includes a body of water to the east of the site, as wind generally flows at higher speeds over smoother surfaces such as water. If several wind turbines are installed, they will need to be placed in manner such that one turbine is about five rotor diameters behind another to avoid fatigue on the blades. In this case the turbines would be placed about 400 m apart along the ridge parallel to the shoreline. The exact layout of such turbines can be optimized in a feasibility stage study.

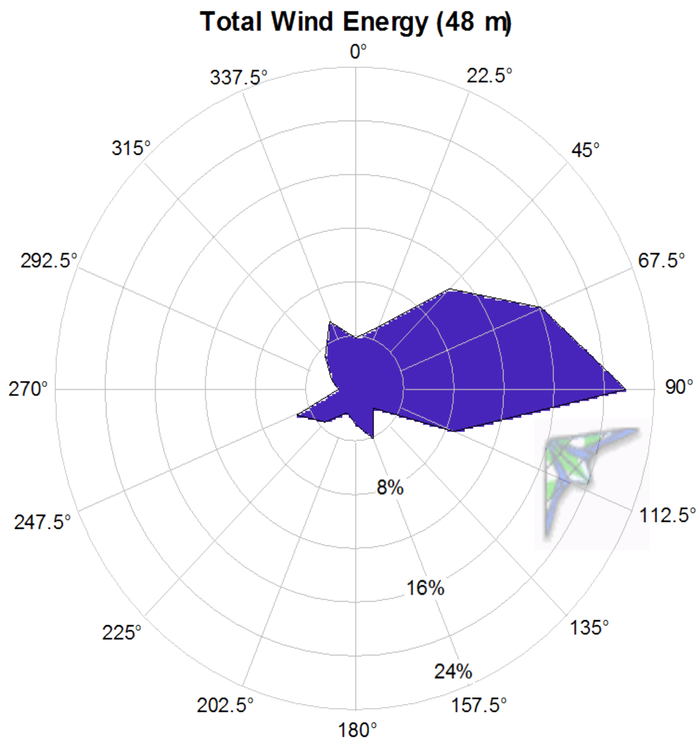

Figure 4: The wind regime at Thor Lake indicates that most of the wind energy comes from the east. The wind rose is based on measurements made at 48 m AGL.

We have now estimated the long-term annual mean wind speeds to be about 6.5 m/s at a hub height of 80 m AGL at the site of the Thor Lake met station. This wind speed estimate should apply to Site #4 and possibly at a new Site #6 (Figure 2). If a lower hub height were chosen (e.g. 60 m), then we may expect the wind speed to decrease to 6 m/s. If the wind turbine was placed further inland at locations such as Site #3 or Site #5 (Figure 2), then wind speeds at an 80 m hub height would likely to drop to approximately 6 m/s (see Pinard 2009). At other locations such as the high ground near the weather station (towards the north of the map in Figure 2), wind speeds at an 80 m hub height may be closer to 5.5 m/s. To confirm these numbers it would be best to either move the met station to the site of interest and measure them, or use a portable LIDAR system which can measure wind speeds at up to 200 m above the ground and can be moved quickly to cover many sites in a relatively short period of time (i.e. a few months).

It should be noted that an airport is being planned for the location shown in Figure 2. This may result in Sites #1 and #3 being inappropriate for a wind park. This airstrip will likely fall under NavCan aviation rules, whereby a proposed wind farm would need to be at least 4 km from the airstrip centre. These rules also state that within 4 km of an airstrip no tall objects can exceed a 45 m ceiling above the airstrip surface. In this case, the proposed airstrip is at about 245 m ASL. Site#1 is approximately 260 m ASL which means a wind tower at Site #1 cannot be taller than 30 m. Effectively speaking, this means that no large scale wind park can be built at Site #1. Similar height limitations apply to Site #3, due to its proximity to the proposed airstrip. For the purpose of this report, we will use the wind speed estimate of Site #1, but the proposed wind location may need to be 4 km from the mine site and airstrip. The most appropriate locations would be towards the east on the high ground next to the shore, where Sites #4 and #6 are located.

Wind Turbine Selected for Study

The GE 1.5sle turbine was selected for use in this desktop analysis of energy production and economics, as it is well suited to the wind regime and climate of the region; the same turbine was used in a comparable study prepared for Yellowknife (Pinard and Maissan 2008). The GE1.5sle is a 1.5 MW wind turbine with a 77 m rotor (diameter) that has been commonly used throughout Canada and is available with a tower of 65 and 80 meters. This model is designed for lower wind speed regimes; compared to most other turbines on the market it has a larger rotor diameter for its capacity[1]. This turbine is available in a cold climate version that allows operation down to -30°C, below which the turbine automatically shuts down.

The energy produced by a GE 1.5sle is based on the published power curve less 5% to adjust for a turbine availability of 95%. An additional 15% of the remaining production is then subtracted to account for losses (turbulence losses, array losses, low temperature shutdown losses, mechanical losses, cold and icing performance losses, transformer losses, and transmission line losses) to arrive at the net energy production available to displace diesel energy. The cold and icing losses is accounted for icing periods and for temperatures below -30°C. Icing does not appear to be severe and is already considered in the reduced wind speed measured during those periods. A more accurate assessment of low temperature losses would need to be determined by detailed analysis of long-term data.

Wind Energy Production

The annual energy production from the selected wind turbine, the GE 1.5sle, is calculated from the HOMER model. HOMER was developed by the National Renewable Energy Laboratory of the US Government and is now distributed and supported by HOMER Energy (www.homerenergy.com). HOMER is a power system analysis and optimization model. The energy model uses published wind turbine power curves, diesel plant production specifications, and a one-year hourly time series measurements of both wind speed and community power load to model the energy output of various power generators.

The proposed mine is estimated to require about 8.4 MW with a variation of -10% to +25%, depending on season and equipment use. This means that the monthly mean mine load is expected to range from about 7.5 MW to 10.5 MW. A data set was synthesized from this information. With these figures the HOMER model calculates a mean energy load of 212,000 kWh per day or about 77 GWh per year. For

[1] Other models are now available such as the GE 1.5xle and the GE 1.6xle which come with an 82.5 m blade and are designed to capture more energy from a lower wind regime. These turbines come with an 80 or 100 m tower.

this exercise we allowed for some degree of variation or randomness in the hourly load where about one-fifth of the hourly load falls below 7.5 MW and the minimum load drops to about 5.8 MW in a given hour. The implication of this is that if the wind plant produces power approaching 7.5 MW (a five turbine scenario) there will be excess wind energy that will not be used to meet the mine load. The diesel plant must also maintain a minimum load ratio to provide stability to the electrical system. In this scenario we have assumed a 20 MW diesel plant with a minimum load ratio of 30% or 6 MW.

It should be possible to install three GE 1.5sle turbines with a total power capacity of 4.5 MW without producing excess energy. A larger wind plant can be installed, but more sophisticated power equipment that can use the excess wind power and/or includes short-term storage would be required. More details of the generator plant and the mine load would be necessary to assess the number of wind turbines that would be optimal for this project. This is beyond the scope of this study and would be more appropriate in a feasibility stage study.

Economic Analysis

At the time of writing Pinard and Maissan (2008), the GE 1.5sle was estimated to cost $4.89 million or $3,260 per kW ($3.26M per MW) installed in Yellowknife. In 2009, three GE 1.5sle wind turbines were installed on Kodiak Island in Alaska for the cost of US$21.4M or at a cost of US$4,760/kW. Kodiak Island is located off the south coast of Alaska, about 400 km southwest of Anchorage. Since the 2008 Yellowknife study, the costs of developing wind energy projects are expected to have increased, but are not expected to be as much as the Kodiak Island project, which was more remotely located.

For the purpose of demonstrating price sensitivity, we will assume that the cost for this type of turbine is $4,500 per kW of installed capacity. This cost includes constructions costs for 4 km of powerline, road building to the site, and crane mobilization and demobilization to Thor Lake. A discussion of development costs will follow. With the above assumptions we will start with a capital cost of$6.75M for a GE 1.5sle wind turbine installed at Thor Lake. Operation and maintenance is assumed to be $150,000 annually for one wind turbine. The cost of borrowing is assumed to be at an interest rate of 8% annually but to gauge cost sensitivity we will also use 5% and 10% as well. The mine is expected to have an 18-year operating life, so this time span was chosen for the financing. With the given interest rate and term length of borrowing the total annualized cost for the initial capital will be $720,239 per year. Adding these annual costs gives us a total of $870,239 per year. Table 3 shows that a GE 1.5sle wind turbine on an 80 m tower installed at site #1 by the shore will produce about 3.06 GWh per year (at 6.5 m/s) for a cost of $0.28/kWh.

Table 3: Sensitivity of production costs of a GE 1.5sle wind turbine with respect to mean wind speed. This assumes an interest rate of 8%, and $4,500/kW installed cost, with an 18-year term for borrowing.

Long-term Mean Wind Speed:	**5.5**	**6.0**	**6.5**	m/s
Annual Wind Energy Production:	2,488,104	3,127,309	3,784,991	kWh/yr
Wind Turbine Availability 95%	2,363,699	2,970,944	3,595,741	kWh/yr
Losses 15%:	354,555	445,642	539,361	kWh/yr
Net Annual Wind Production:	2,009,144	2,525,302	3,056,380	kWh/yr
Capacity Factor:	15.3%	19.2%	23.3%	%
Total Annual Cost:	$870,239	$870,239	$870,239	per year
Wind Energy Production Cost:	$0.43	$0.34	$0.28	per kWh

The turbine may need to be on a shorter tower of, say, 65 m or the location of the wind plant may need to be further inland where the mean wind speed will drop to 6.0 m/s. At this wind speed, the wind plant is expected to produce 2.5 GWh per year at a cost of $0.34 per kWh.

The production cost sensitivity to varying interest rate is shown in Table 4. If a lower end interest rate of 5% can be achieved, this would reduce the wind energy production cost to $0.24/kWh.

Table 4: Sensitivity of wind energy production costs with respect to interest rate. This assumes a wind speed of 6.5 m/s at an 80 m hub height, and $4,500/kW installed cost, with an 18-year term for borrowing.

Interest Rate:	**5%**	**8%**	**10%**
Total Capital Cost:	$6,750,000	$6,750,000	$6,750,000
Annualized Cost:	$577,437	$720,239	$823,029
An. Oper. & Main. Cost:	$150,000	$150,000	$150,000
Total Annual Cost:	$727,437	$870,239	$973,029
Production Cost per kWh:	$0.24	$0.28	$0.32

Yet how does the cost of wind energy compare to the cost of diesel? Table 5 shows the cost of diesel-generated electricity as a function of different fuel prices. If the cost of the fuel brought to the mine site is $1 per litre, then diesel-generated electricity will cost $0.29 per kWh.This is the same price per kWh as installing a wind turbine at site #1. If an inflation rate of 2% is to be factored into the diesel cost, then the levelized cost of energy from diesel-generated electricity would add about $0.04 per kWh to the diesel electricity costs in Table 4.

Table 5: Diesel electricity value per kWh as a function of diesel fuel cost, assuming a diesel plant efficiency of 3.5 kWh per litre.

Fuel cost per litre	Diesel electricity cost per kWh
$ 0.80	$ 0.23
$ 0.90	$ 0.26
$ 1.00	$ 0.29
$ 1.10	$ 0.31
$ 1.20	$ 0.34
$ 1.30	$ 0.37

Other factors are also considered which will affect the capital costs of a wind project in Thor Lake. The most economical link from Yellowknife to Thor Lake will likely be by winter ice road which is a distance of about 130 km. Power lines in the NWT are estimated to cost approximately $250k/km by utility standards; therefore, for Thor Lake, the power line from the wind farm to the mine will cost between $0.5M and $1M, since the wind project will likely be located 4 km from the mine site to avoid interference with the airstrip. Reducing the distance by 2 km would translate into savings of $0.02/kWh. The power line is a fixed cost, which means the addition of more turbines will reduce the cost per kW of the wind plant (see Table 7). If the wind plant can be built at the same time as the mine, then costs for the wind project will also be reduced.

The sensitivity of the wind energy production cost to the capital cost of a wind plant is examined in Table 6. Here we can see that if the wind plant cost can be reduced to $3,500 per kW, the cost of wind energy production will drop $0.23 per kWh.

Table 6: Production cost of wind energy based on estimated cost per MW of installed capacity under a long-term mean wind speed of 6.5 m/s at an 80 m hub height (8% interest on an 18-year borrowing term). The net annual production of the GE 1.5sle for this wind speed is 3.06 GWh/yr.

Cost per installed kW:	$3,500	$4,000	$4,500	$5,000	$5,500
Total Capital Cost:	$5,250,000	$6,000,000	$6,750,000	$7,500,000	$8,250,000
Annualized Cost:	$560,186	$640,213	$720,239	$800,266	$880,292
An. Oper. & Main. Cost:	$150,000	$150,000	$150,000	$150,000	$150,000
Total Annual Cost:	$710,186	$790,213	$870,239	$950,266	$1,030,292
Production Cost per kWh:	$0.23	$0.26	$0.28	$0.31	$0.34

An assessment of the optimum number of wind turbines is given in Table 7 below, which shows the production cost in relation to the number wind turbines. The capital costs include a 4 km power line, a 4 km road, and mobilization and demobilization of a crane to the site. These are fixed costs, and will have an estimated price of $1.3M (almost 20% of the cost the installed wind plant if only one GE 1.5sle turbine is used[2]). This fixed cost will become less significant with more turbines installed.

If more than two turbines are installed, some excess energy may exist when the mine load drops and the diesel plant reaches its minimum load limit. Excess wind energy increases with four and five wind turbines added to the system. In this case, when excess wind energy exists, the excess can either be avoided by reducing the power output of one or more wind turbines, or dumped into a secondary heat load. The secondary heat load may be useful in the winter or may be less so if is produced in the summer. This is the subject of some creative engineering which would be carried out in a feasibility stage study.

Table 7: A cost-benefit breakdown of a wind power plant as a function of the number of wind turbines. The net annual production of wind energy is the amount used by the mine load and does not include the unused wind energy portion noted in the table. The wind penetration is the net annual wind energy produced divided by the total energy load of the mine, which is 77 GWh/year.

# of Wind Turbines:	1 GE 1.5sle	2 GE 1.5sle	3 GE 1.5sle	4 GE 1.5sle	5 GE 1.5sle	
Power Capacity:	1.5	3	4.5	6	7.5	MW
Net Annual Production:	3,056,380	6,112,760	9,168,498	12,161,771	14,739,060	kWh/yr
Unused Wind Energy:	-	-	624	63,750	542,796	kWh/yr
Wind Penetration:	4%	8%	12%	16%	19%	%
Total Capital Cost:	$6,839,000	$12,009,000	$17,179,000	$22,349,000	$27,519,000	
Cost per kW:	$4,559	$4,003	$3,818	$3,725	$3,669	per kW
Annualized Cost:	$729,736	$1,281,385	$1,833,035	$2,384,685	$2,936,335	per year
Annual O&M:	$150,000	$300,000	$450,000	$600,000	$750,000	per year
Total Annual Cost:	$879,736	$1,581,385	$2,283,035	$2,984,685	$3,686,335	per year
Production Cost:	$0.288	$0.259	$0.249	$0.245	$0.250	per kWh

The excess wind energy could be stored in a battery bank, or a flywheel, which could be used as a power stabilizer for the electrical system, thus allowing the diesel plant to reduce its minimum load limit. Such storage systems are typically expensive and somewhat inefficient, as energy is lost when it is stored and again when it is later extracted from the storage bank.

Regardless of whether the excess wind is simply dumped, used to heat buildings, or stored in a battery bank, the efficiency of the wind system will drop with rise in excess wind energy. The present technology to handle excess wind energy is still evolving. As a result, the production costs for this scenario reaches a minimum at three or four turbines and increases with more than four turbines in the wind energy plant. Again, this would be a subject for a feasibility stage study.

[2] The site of interest in this case is Site #6 shown in Figure 2.

Funding Sources

Renewable power generating projects may be eligible for capital cost allowance deductions under Class 43.1/Class 43.2 of the federal income tax regulations. Information on the applicability of these deductions can be found through the Class 43.1/43.2 Secretariat.

A program called the Northern and Remote Wind Incentive Program (NoRWIP) is being proposed by the Canadian Wind Energy Association (CanWEA) for funding under the 2011 federal budget. This program is designed to spur development of wind-diesel systems in Canada's northern industrial facilities and remote communities.

Under this program, the Thor Lake mine would fall into wind energy development category #1: a large northern industrial facility with an average electrical load of 2 MW or higher. For this category, NoRWIP would provide a contribution of $250,000 on completion of feasibility studies to specified standards, as well as a capital contribution of up to $1,000 per kW or 20% of project budget, whichever is less. This contribution would be made in two parts: the first would be 50% of the amount specified above at the time a firm order for wind turbines is placed; the second payment would be made on commissioning of the project and 90% or more of the actual project costs confirmed. Applying the contributions of $250,000 and $1,000 per kW to this project will reduce the wind energy production cost by about $0.06 per kWh.

Greenhouse Gas Reductions

The calculations of greenhouse gas (GHG) emissions savings are based on GHG emissions of 2.83 kg carbon dioxide equivalent (CO_2e; based on the GNWT's figure for non-motive diesel) per litre of diesel fuel consumed. The diesel plant heat rate is assumed to be 3.5kWh per litre. The GHG production is calculated as 0.8086 kg of CO_2e per kWh. Using these figures, the GHG reductions that would result from each of the wind project configurations described in Table 7 are calculated and presented in Table 8 below. A four-turbine wind power plant would save the mine operation 3.5 million litres of diesel fuel and 9,800 tonnes (CO_2e) of GHGs annually.

Table 8: Annual GHG reductions from the wind plant configurations described in Table 7.

	1 GE 1.5sle	2 GE 1.5sle	3 GE 1.5sle	4 GE 1.5sle	5 GE 1.5sle	
Diesel Energy Displaced:	3,056,380	6,112,760	9,168,498	12,161,771	14,739,060	kWh/yr
Diesel Fuel Displaced:	873,251	1,746,503	2,619,571	3,474,792	4,211,160	litres/yr
GHG reduction:	2,471,302	4,942,603	7,413,386	9,833,660	11,917,583	kg CO_2e/yr

Conclusions

The wind measurements from September 2009 to September 2010 were analysed and show evidence of a moderate wind climate for wind energy production. The main direction of the wind is from the east, and the best winds are calculated to be on the high land towards the shoreline of the Hearne Channel. A large scale wind turbine was used for the economic analysis in this study; specifically, the GE 1.5sle. An analysis of sensitivity to wind speed, installed cost, interest rates, and number of wind turbines were performed.

A wind park of four large scale wind turbines like the GE 1.5sle with total wind capacity of 6 MW is likely the optimum size for the mine load. For this size of wind park, a cost $22.3M or $3,700 per kW of installed capacity should be achievable. At a production cost of $0.25 per kWh. a wind project at Thor Lake can compete with diesel-generated electricity. With the NorWIP program in place, this will bring the cost below $0.20 per kWh for wind energy produced at Thor Lake.

Recommendations

There is enough information here to help the mine owners to consider the possibility of a wind project at Thor Lake. If Avalon Rare Metals wishes to pursue this project the next steps could involve the following:

1. Join CanWEA and lobby the Federal Government for the NorWIP.
2. Consider building the wind park at the same time as the mine.
3. Consideration should be given to relocating the airstrip further north to allow the wind park to be located closer to the mine site.
4. Wind speed is critical to the economics of a wind project. If there is serious interest for developing wind but at an alternative site from Site #1 then the met station should either be relocated to the new site or a LIDAR monitoring program will serve to confirm the wind climate at several locations of interest.
5. Upon confirmation of the decision to proceed with a wind project for this mine, a detailed feasibility study should be carried out. Attention should be given to minimizing capital costs and identifying any available support programs. Part of the feasibility would include:
    a. permitting and environmental work,
    b. wind flow modelling,
    c. wind monitoring at the selected site or a LIDAR monitoring program,
    d. geotechnical study and foundation design for towers, and
    e. electrical engineering which would include assessing options for turbines and technology relating to wind-diesel integration.

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