Norman Wells Wind Energy Pre-feasibility Report

Prepared for

AURORA RESEARCH INSTITUTE
AURORA COLLEGE

Inuvik, Northwest Territories

by

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Executive Summary

The community of Norman Wells has a population of about 850 whose power is provided by Northwest Territories Power Corporation (NTPC). The current electrical load is about 9,368 MWh per year, and almost all of the purchased power is generated by natural gas. Overall the community of Norman Wells and its resources are well suited to a wind project.

A potential wind development project site has been identified close to the community on a ridge to the Northwest of the community called Kee Scarp. This location has a projected wind resource of 6.5 m/s, but confirmation by an on-site monitoring tower of 50 or 60 meters is required.

The community and its electrical load are large enough to allow some economies of scale in a wind project. Wind energy projects of 300 and 500 kW were estimated to cost $2.646 million and $3.522 million respectively ($8,820 and $7,044 per kW of capacity). The marginal capacity was estimated to cost about $4,400 per kW. A “lowball” estimate for the 500 kW project was $2.697 million ($5,394 per kW).

The energy produced from an unsubsidized wind project was estimated to cost $0.472 per kWh from the 300 kW project and $0.395 from the 500 kW project. The marginal capacity would produce power at $0.28 per kWh, probably the same as the current diesel generation cost. A proposed ReCWIP type of support program ($0.15 per kWh) would result in the 500 kW project producing power at the equivalent to diesel fuel at $1.00 per litre. The 300 kW project would then produce power at the equivalent of $1.20 per litre of diesel fuel.

In the North the impact of capital costs on the cost of wind energy is still significant. The authors believe that it is necessary, under a long-term territorial strategy, to develop successful wind projects in the Canadian North, so that capital costs, operating costs, and wind turbine performance can be accurately determined and streamlined.

Given more favourable conditions Norman Wells can have a commercially competitive wind energy project. Getting the federal government to adopt the proposed ReCWIP program is very high on the Canadian Wind Energy Association’s list of priorities, and would make a significant difference to the project. Any other advantages such as a wind resource in excess of 6.5 m/s, or reduced capital cost, or reduced operating cost, or increased diesel fuel cost (or revenue from carbon credits or green attribute sales) would serve to further increase the competitiveness of a wind project.

A diesel displacing 300 kW project would reduce GHG emissions by over 523 tonnes per year and a 500 kW project would reduce GHG emissions by over 872 tonnes per year.

The most important next step towards a wind project in Norman Wells is the installation of a wind monitoring tower on the proposed development site on Kee Scarp.

Background

JP Pinard, P.Eng. Consulting Engineer, and John Maissan, P.Eng. Leading Edge Projects Inc. have been retained by the Aurora Research Institute to conduct a pre-feasibility study for wind energy generation in Norman Wells. 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. In addition the project group has consulted with the hamlet of Norman Wells, NTPC and Imperial Oil about the current and future power systems in Norman Wells. 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 near Norman Wells.
3) Size, capacity and condition of present power system in Norman Wells.
4) Analysis of different scenarios of power demands for Norman Wells.
5) Preliminary estimates of the cost of wind generation for Norman Wells.
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 Norman Wells.

Introduction

The Northwest Territories has in the past developed wind projects which have failed in large part due to capital costs overruns, and technical immaturity of wind turbines for remote Northern communities. With wind projects now serving seven remote communities in Alaska, the state has reached 1.6 megawatts (as of January 2008) of installed wind capacity. The success there is proving that community-scaled wind turbines have come of age. It is for this reason that wind energy in the NWT has regained attention. Since 2003 the Aurora Research Institute has been actively researching the wind energy potential in the NWT.

Norman Wells has a population of about 850 with an expected growth to 950 by 2011. It is located 700 km northwest of Yellowknife and it is located on the Mackenzie River. The community is accessible by barge during the summer, and connects to NWT's year-round highway system during the winter on a winter road.

The gas fields near Norman Wells have been in decline for some time; this is a problem because currently all of the power and most of the heat in Norman Wells has been generated with natural gas. In the short term, the solution for community energy demands appears to be the utilization of diesel to generate power, resulting in increased economic and environmental costs associated with burning imported fossil fuels (see Appendix 2). So with the likely introduction of diesel generation in the community wind energy will become a favourable compliment to keeping the diesel consumption to a minimum. This may change if the Mackenzie Gas Project (MGP) is developed but at this point the MGP is not a certainty.

Some preliminary work on the wind energy potential in the community was carried out in the fall of 2006 and the following factors were identified in Norman Wells:

- Abundance of technical (human) resources;
- A large 13 megawatt (MW) gas plant run by Imperial Oil (the plant will shut down and loads will be reduced as industrial activity drops);
- A promising wind resource (long-term mean above 6 m/s) and a high site located near town; and
- Mackenzie River location ideal for barging large project components and machinery.

Suitable sites for wind energy development

When selecting a suitable site for a wind energy development the most important considerations are site elevation, orientation, site accessibility, and distance to existing power lines. The wind turbines should have high exposure to the dominant wind directions (ideally, a hilltop ridge should be perpendicular to the dominant wind directions).

The community is located in a 50-km wide valley bordered by the Mackenzie Mountains. The Carcajou Range (Mackenzie Mountains) is 40 km to the southwest, and the Norman Range is10 km to the northeast. The Norman Range is a narrow ridge oriented west-northwest, it averages about 850 m above sea level (ASL) and peaks at 980 m ASL. However, this ridge could not be considered as a potential wind monitoring site since there is no road access to the site and it is too far from existing power lines.

Kee Scarp is a hill that is 5 km to the northeast of Norman Wells and is readily accessible by road. It peaks at about 350 m ASL, or 275 m above the town site. The hill is narrow with the long axis oriented west-northwest, parallel to the Norman Range. There is a 6-km long road that leads from the community to the southeast end of the ridge where a clearing exists (Figure 1) The clearing is at about 303 m ASL, accessible by car and is large enough to accommodate a 60-m guyed tower. This site could be considered for and wind project (or initially a wind monitoring station).

A more suitable but less accessible site for a wind project is located 1.2 km west-northwest of the clearing, at the highest area on the ridge. It is accessible via a trail on the northeast edge of the ridge that leads through the area (labelled proposed area for wind development Figure 1). The trail is accessible only by all-terrain vehicles and can be muddy (Figure 2). The forest on the ridge is fairly dense with a mixture of poplar, birch, and spruce (Figure 3). The trees range from 6 to 8 metres in height. Figure 4 shows an aerial view of the proposed wind farm area with the trail leading through it. This area is about 80% covered with forest with long strips of clearing running parallel to the ridge.

The proposed wind farm location appears to be the highest area on the hill. The land gradient in both dominant wind directions is very shallow (Figure 5).

There are three weather monitoring stations (maintained by Environment Canada) that have been identified in Norman Wells: i) the airport station; ii) the upper air station; and, iii) a forestry weather station. The airport station (labelled NW A in Figure 1) is about 72 m ASL and located at the air field. The upper-air station (labelled YVQ UA, Figure 1) is at 95 m ASL and is in a small clearing partway towards the Kee Scarp. About halfway between the clearing and the proposed wind development site is a small forestry weather-monitoring station that is at 340 m ASL (Figure 6). This station was only a few metres tall and the anemometer is well below the height of the forest canopy and therefore can not provide useful information about the wind potential there.

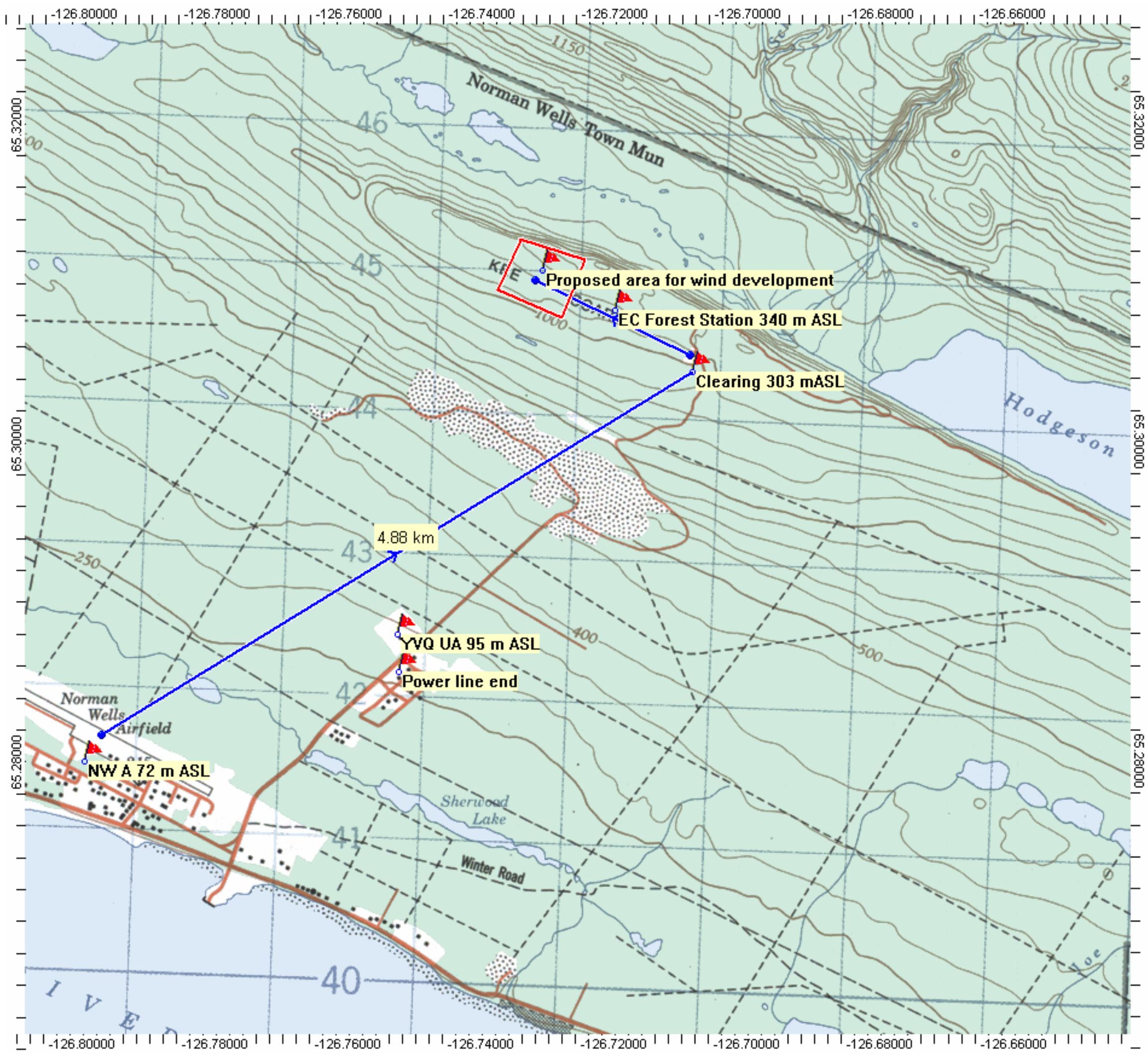

Figure 1: Map of Norman Wells and the Kee Scarp. The contour interval is 50 feet.

Figure 2: ATV trail about one hundred metres from the gravel road.

Figure 3: From the EC forestry station looking south towards Norman Wells. Note the Carcajou Range and the Mackenzie River in the background. The trees in the forest are 6 to 8 metres tall.

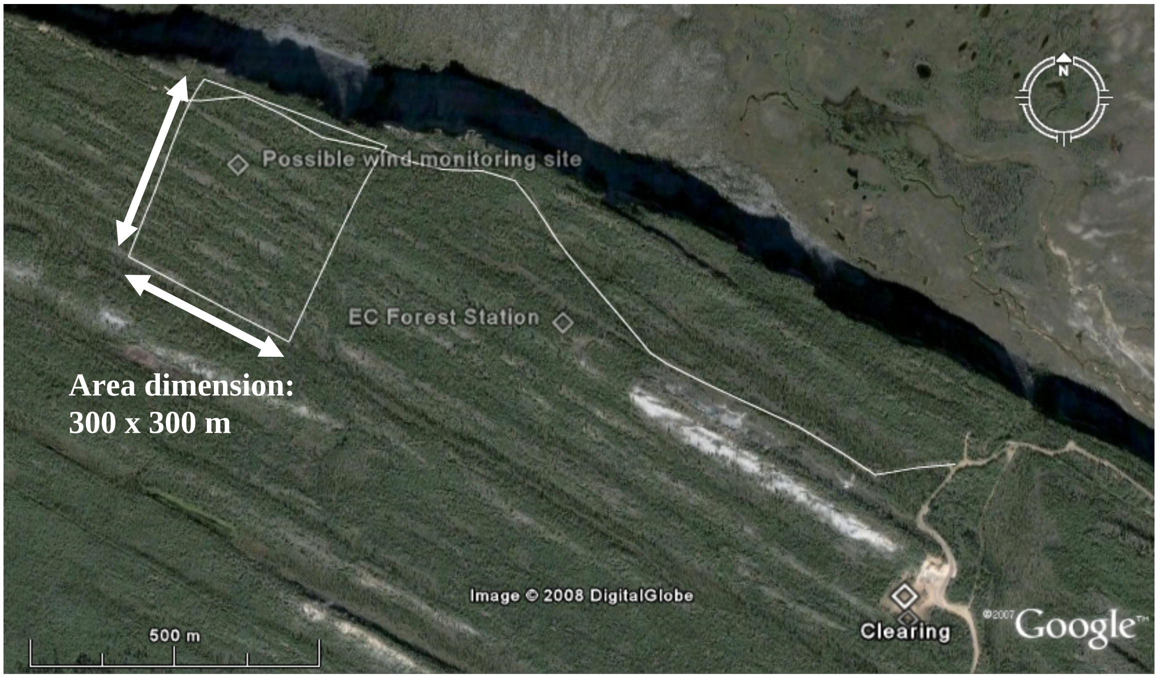

Figure 4: Aerial view of the area where a wind monitoring tower could be installed. An ATV trail (white line) leads to the site from the gravel road at the right of the figure.

Figure 5: Photo of the Kee Scarp looking northeast from the airport terminal.

Figure 6: Environment Canada (EC) forestry station, looking north.

Measured and Projected Wind speeds and Directions

The measurements used in the wind analysis are mostly from the radiosondes (upper-air or weather balloon measurements) which have been released at 12-hour intervals since the mid-1950s. The upper-air measurements are particularly useful for determining wind direction and wind speed at elevations well above the surface. The data also provides useful information about long-term trends in the wind climate on the area. More details about the upper-air measurements can be found in Appendix 1. Other wind measurements used in this report are from the surface weather stations at airport (72 m ASL) and the upper-air station (95 m ASL) both of which have 10 m tall towers and their wind speed data are usually recorded hourly.

The wind rose in Figure 7 shows the wind energy by direction, which 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. The two dominant wind energy directions above Norman Wells approximately follow the axis of the valley. About 49 % of the wind energy comes from the northwest and 46% comes from the southeast. In the winter the wind is distributed nearly equally between the two directions, whereas in the summer the northwest wind is more dominant (63%).

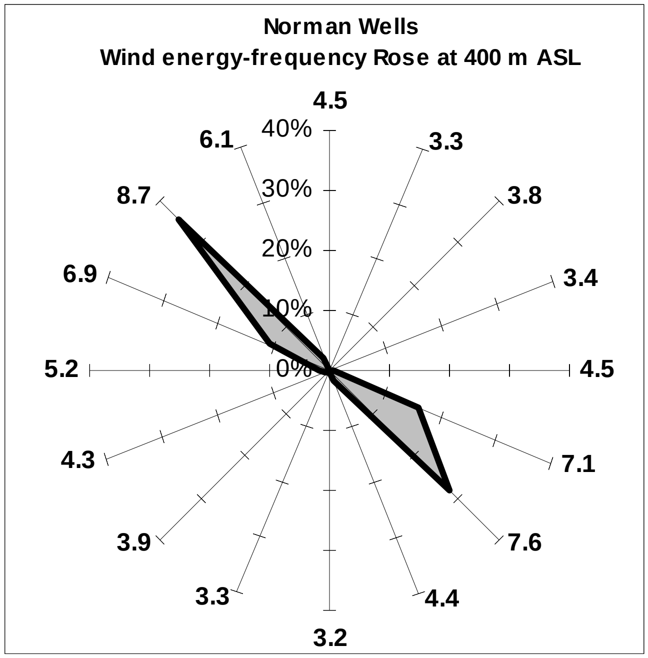

Figure 7: Wind energy-frequency rose is from the upper-air measurements for the period 1998-2007. These measurements are estimated at 400 m ASL or about 50 m above the top of the nearby Kee Scarp. The rose shows the dominant wind energy directions as a percentage of the total in all directions. The mean wind speed by direction is shown at the end of each axis.

The two dominant wind directions are superimposed with white arrows over a three-dimensional aerial perspective of the Kee Scarp site (Figure 8). In this view the airport station and the town are to the southwest of the ridge and are located at the top left of the figure. The figure also identifies the ATV trail and the proposed wind farm area. The two arrows show the dominant wind directions; W_{E1} indicates the wind from the northwest and W_{E2} shows the wind from the southeast. Wind turbines are typically placed in a row perpendicular to the prevailing wind direction. In this case however the ridge is parallel to the dominant wind directions, this will change the site layout and while some turbines may be placed at the ridge top, others may need to be placed lower down the slope.

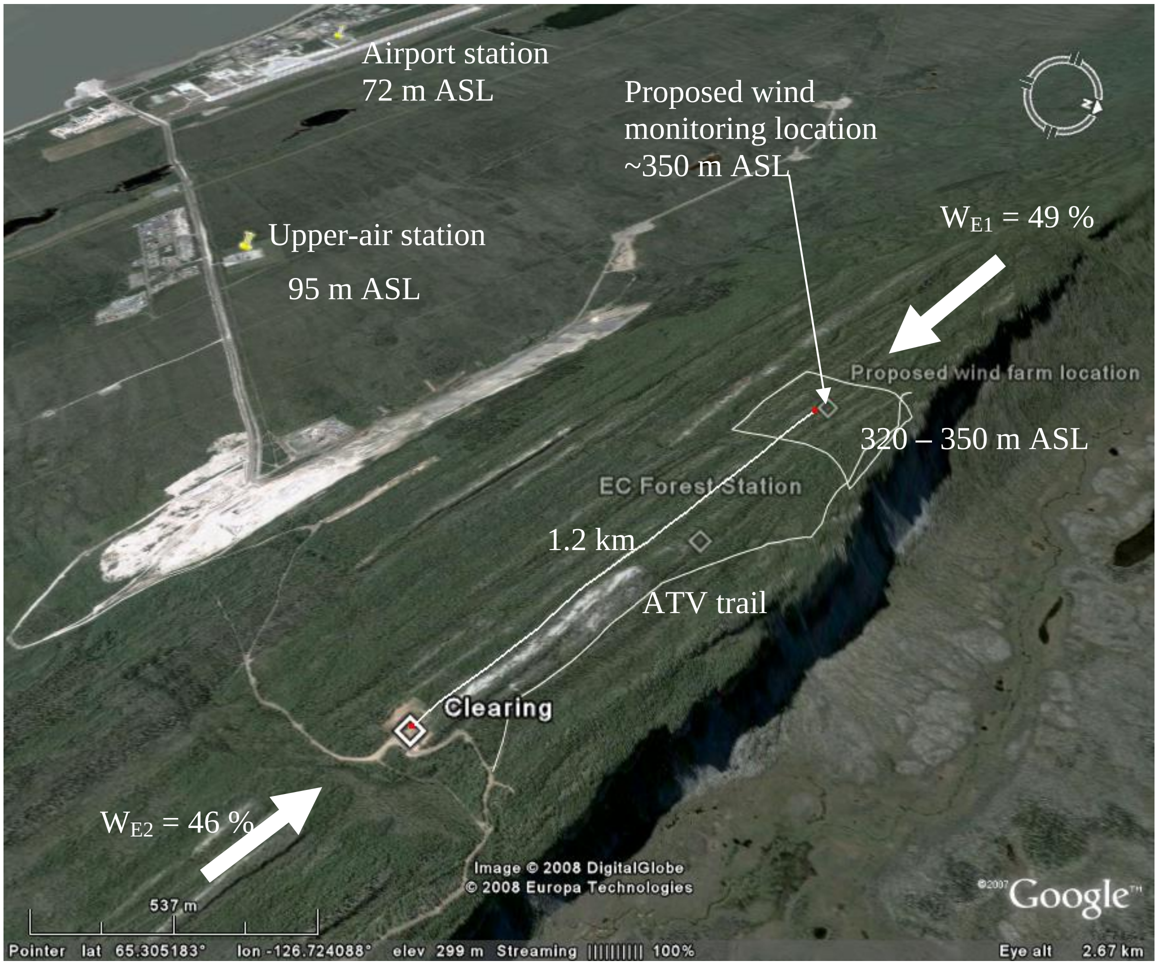

Figure 8: A three-dimensional perspective view of Kee Scarp. The proposed wind farm location is likely the highest area on the hill.

A long-term mean annual wind speed above 6 m/s at a turbine hub height is typically required for a wind development to be considered feasible. The surface wind speeds measured (at 10 m above ground level, AGL) at both the airport (72 m ASL) and the upper-air stations (95 m ASL) were below 3 m/s. At 50 m above ground at these two sites, the mean wind speed is estimated to also be just below 5 m/s.

A vertical profile of the ten-year mean wind speed from the upper-air measurements is shown graphically (Figure 9). The profile shows that the wind speed increases almost linearly from 2.5 m/s at the surface (10 m AGL) to 6.4 m/s at 300 m ASL. The linear increase is due to a reduced number of measurements between the two levels, please see appendix 1 for more information. The measurements are more accurate at elevations 300 m ASL and higher. At elevations 300 and 400 m above sea level (ASL), the ten-year mean wind speed (1998-2007) is estimated to be between 6.4 and 6.6 m/s. The ground surface elevation at the peak of Kee Scarp is 320 to 350 m ASL.

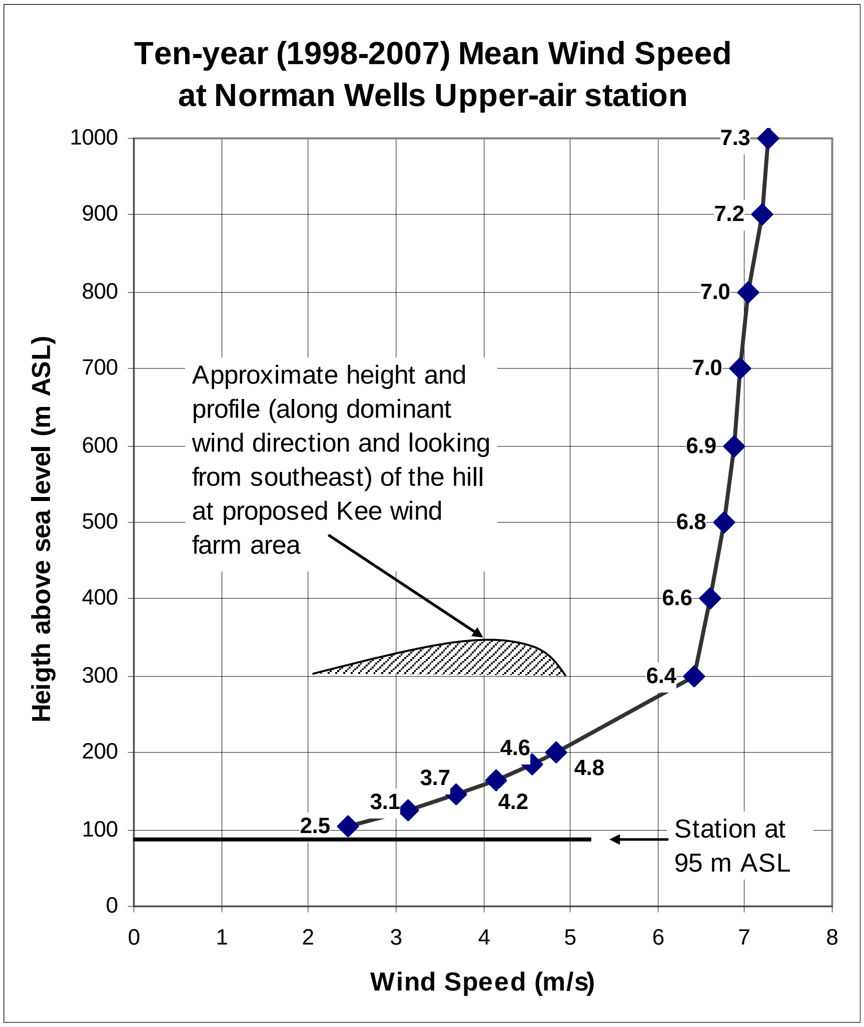

Figure 9: Vertical profile of ten-year annual mean wind speed above the Norman Wells upper-air station.

The wind speeds measured above the upper-air station are considered free-air measurements because they are relatively undisturbed by surface roughness and localized topography. The proposed hilltop area at Kee Scarp is a very short distance at 2.7 km north-northeast of the upper-air station and the free-air wind speed above the hilltop is not likely to deviate significantly from those above the station. Near the surface of the hilltop there are factors that could diminish or increase the wind speed. The surface roughness of the forest may cause turbulence and diminish the wind speed, particularly in the first 10 to 20 metres above the surface. The slope of the hill however, may cause a local speed-up in the wind. The ridge is narrow and parallel to the dominant wind direction which means that the wind speed-up will not be necessarily be large. The most effective way to determine how the mean wind speed is influenced at the Kee Scarp hilltop is to measure it at the site.

For the purpose of this study we will assume that there is no difference between the upper-air measurements of wind speed at 350 m ASL and at 30 m above the surface the hilltop, which is also at 350 m ASL. At 350 m ASL the estimated ten-year (1998-2007) annual mean free air wind speed is 6.5 m/s with a standard deviation of 0.5 m/s. The 53-year (1955-2007) mean wind speed, however, is 5.4 m/s (the standard deviation is 0.8 m/s). Looking at Figure 10 we can see that the last ten years have been the highest since records began. At 350 m ASL the lower wind speed values in the 1980's likely reflect the lack of measurements near surface throughout that decade (there is a similar situation at other upper-air stations, e.g. Whitehorse). The wind speed at 1200 m ASL is less erratic and shows a nearly constant increase in the mean wind over the last five decades. The long-term trend shows that the winds have increased by about 0.7 m/s at 1200 m ASL and 1 m/s at 350 m ASL. This is a similar trend to Whitehorse and Inuvik where weather balloon measurements are also made (Pinard 2007).

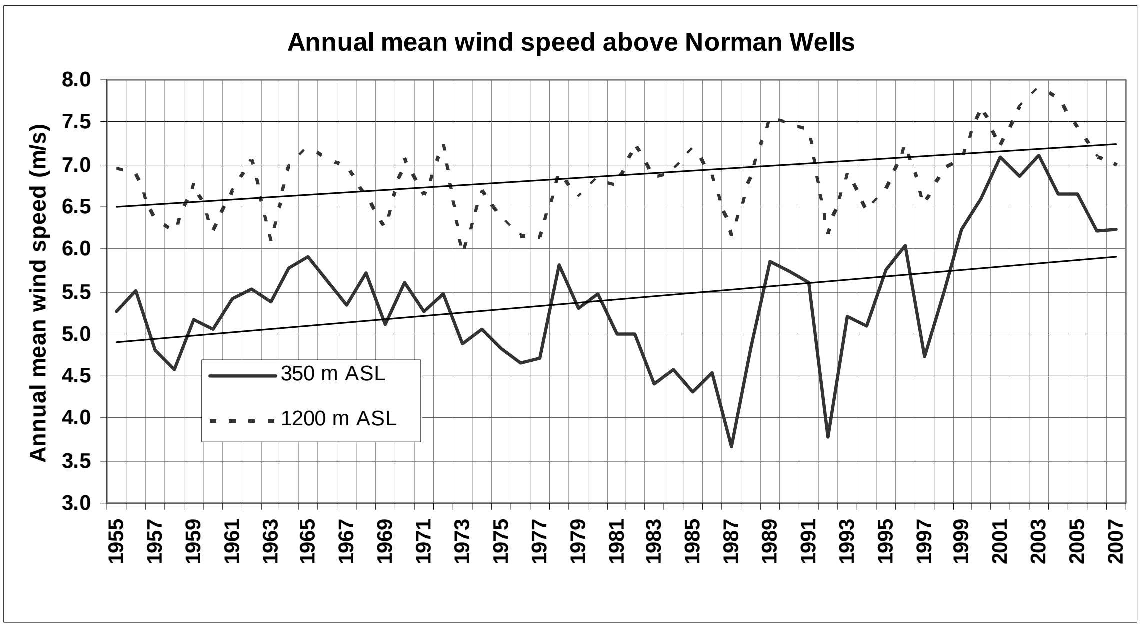

Figure 10: Time series of annual mean wind speed above the Norman Wells upper-air station at comparable heights to Kee Scarp.

This upward trend is likely linked to climate change that is causing a long-term warming in this region. Figure 11 shows the long-term temperature increase through the annual, January, July means over the last five decades. While annual mean temperature increased by 3°C over the last five decades, the largest seasonal increase occurs in the winter as is indicated by the January series. The January mean temperature has increased by about 7°C while the July mean has increased by only 2°C.

The monthly mean wind speeds for the ten-year period 1998-2007 are shown in Figure 12. At 350 m ASL the monthly mean wind speed varies from a low of 5.6 m/s in May to a high of 7.3 m/s in November and December. At the surface of the upper-air station and the airport station, the winds decrease in the winter due to winter inversions. When inversions occur the lowest temperatures are found at the valley bottoms and are a common occurrence in the winter. The resulting denser air in the valley bottom becomes more difficult to move by the faster winds above. The Kee Scarp site is high enough above the inversion layer to experience the same increased winter winds as measured at 350 m ASL, above the upper-air station.

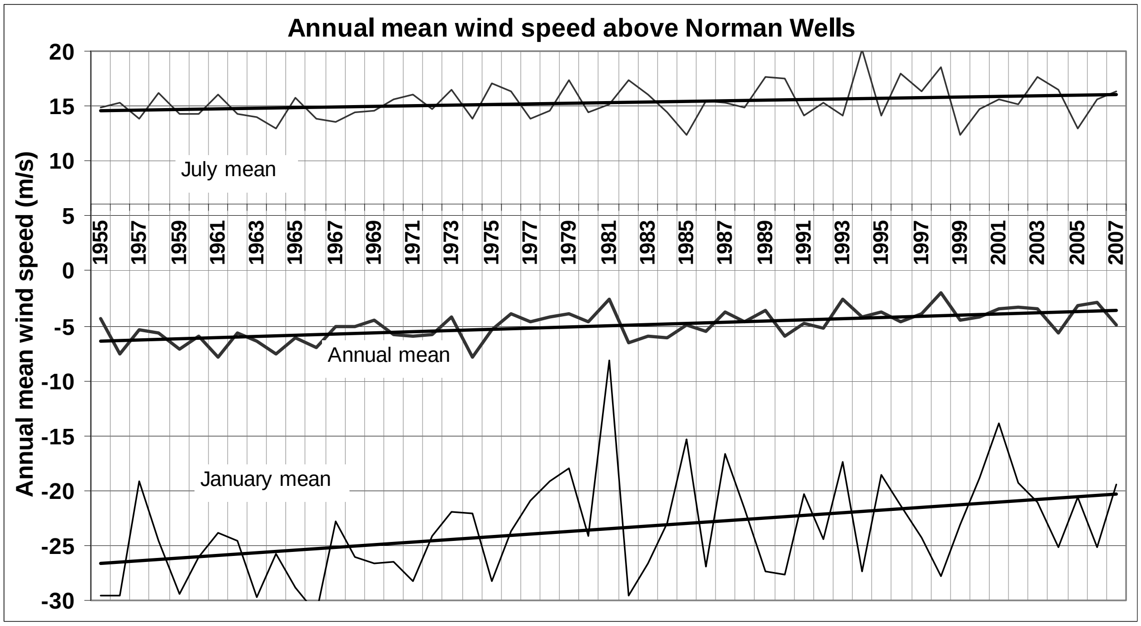

Figure 11: Time series of annual mean air temperature above the Norman Wells upper-air station at comparable heights (400 m ASL) to Kee Scarp.

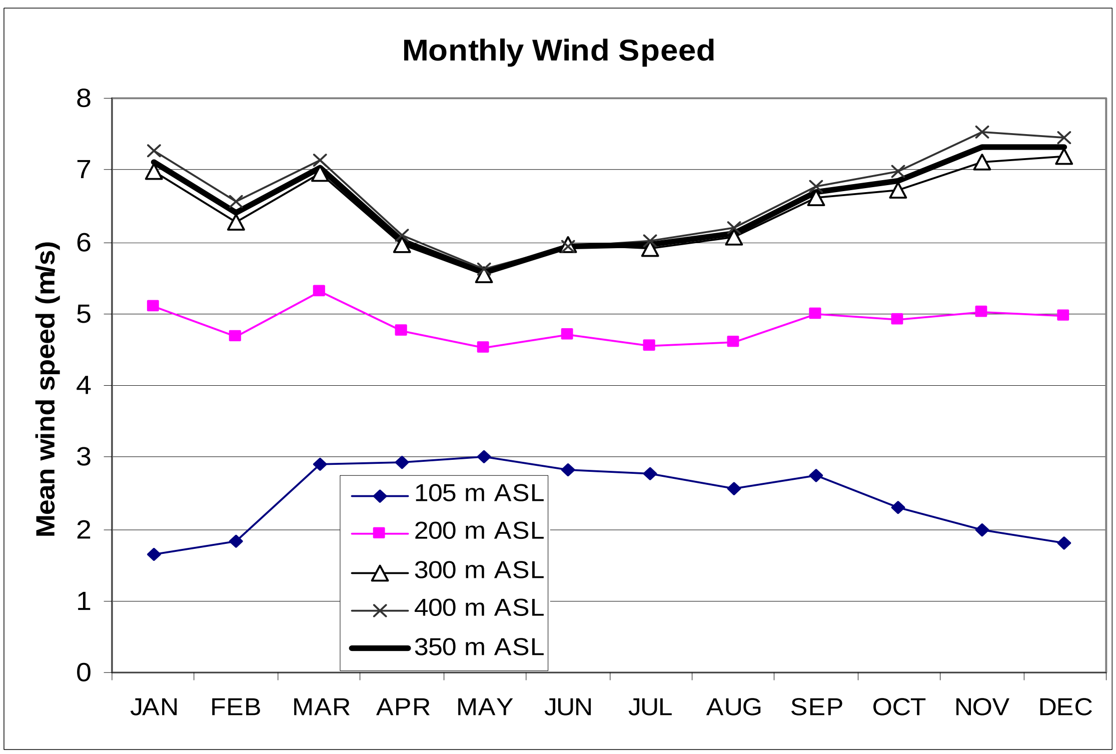

Figure 12: Long-term (1998-2007) monthly mean wind speed at select elevations above the Norman Wells upper-air station. The station is at 95 m ASL and the surface measurements are made at 10 m AGL or 105 m ASL.

Power requirements and costs

The community of Norman Wells has two power supplies. Imperial Oil operates a 13 MW gas fired power plant to serve the oil related industrial loads in the area and sells power to NTPC for distribution to serve the local community's residential and general service loads and street lights. NTPC owns and operates a diesel plant composed of a Caterpillar 3516 rated at 1,400 kW and a Caterpillar D399 rated at 720 kW. This plant provides a small amount of diesel generation to augment the power purchased from the gas power plant.

In the General Rate Application (GRA) of November 24, 2006 NTPC forecasted that their total power requirement for the community was 9,368 MWh of which over 99% would be purchased from Imperial Oil at $0.279 per kWh (indexed to the price of diesel) and the remainder would be diesel generated at $0.246 per kWh ($0.841 per litre and 3.414 kWh per litre). Relevant excerpts of the GRA are attached as Appendix 2.

The annual energy requirement of 9,368 MWh indicates an average load of 1.069 MW and the forecasted peak load is 1.643 MW (a load factor of 65.1%). These figures suggest that the minimum load is likely in the 500 to 600 kW range. For this prefeasibility study, project sizes of 300 kW and 500 kW were considered and are consistent with a medium-low to medium-high penetration level. Although this study did not examine a high penetration project, this would be worth considering equally seriously.

The authors understand that the supply of gas may be running low and that NTPC may be required to supply all of the community power demand from diesel generation in the relatively near future. For the purposes of this prefeasibility study it has been assumed that the industrial loads would continue to be served by privately owned power plants and are thus not included in this study. It has also been assumed that NTPC would install a state of the art diesel power plant that would generate 3.7 kWh per litre of diesel fuel. This efficiency would result in a power cost of $0.243 per kWh with diesel fuel at $0.90 per litre, and $0.351 per kWh for fuel at $1.30 per litre (see Appendix 3).

Wind power project costs

Wind turbines

Based on recent work for a potential wind project for Tuktoyaktuk (Maissan, 2008), three wind turbine models would be suitable for consideration at Norman Wells. Of these the Wind Energy Solutions 18/80 was rejected as it was noticeably more expensive than Entegrity's EW 15 and Distributed Energy's NorthWind 100 (with a 21 meter rotor). For convenience the NorthWind 100 with a 21 meter rotor is referred to as the NW 100-21 in this report. These latter two turbines were estimated to cost about the same (installed) on a per kW of capacity basis. They were then compared on the basis of the energy they would produce in the conditions estimated to be found on Kee Scarp.

The forecasted long term average annual wind speed on Kee Scarp is expected to be 6.5 m/s plus or minus 0.5 m/s. At 6.5 m/s annual average wind speed the energy projected to be produced by the NW 100-21 (per unit capacity) is about 12.3% higher than the energy produced by the EW 15. The advantage of the NW 100-21 increases to 16.2% at a wind speed of 6.0 m/s and decreases to 10.1% at a wind speed of 7.0 m/s. See Appendix 4. Given the significant advantage of the energy production from the NW 100-21, it was decided to base this prefeasibility study on the NW 100-21.

Energy production

The energy produced by a NW 100-21 is based on the published power curve (as yet to be verified in actual field performance) less 5% to adjust for a turbine availability of 95%. An additional 10% of the remaining production is then subtracted to account for losses (turbulence losses, array 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. Appendix 5 is a table of energy production at different annual average wind speeds. Often there is an adjustment for increased production at higher air densities due to cold temperatures which, in this case, would likely be 5% or a bit higher. However, given that the power curve has yet to be verified and the various other uncertainties in the project, it was thought prudent not to add that possible increase into the forecast energy production.

The calculations indicate that the net energy production at an annual average wind speed of 6.0 m/s represents a capacity factor of 22.2%. This increases to 26.0% and 29.9% at annual average wind speeds of 6.5 and 7.0 m/s respectively.

Capital costs

The estimated capital costs for 300 kW and 500 kW projects are presented in Appendix 6. A 300 kW project was estimated to cost $2.646 million or $8,820 per kW, and a 500 kW project was estimated to cost $3.522 million or $7,044 per kW. A "lowball" estimate for a 500 kW project was $2.679 million or $5,394 per kW. The cost difference between the 300 kW project and the 500 kW project was $876,000 or $4,380 per kW.

The most significant fixed cost items (not a function of project size) are the power line estimated at $787,000 (4.5 km at $175,000 per km), the integration with the diesel plant estimated at a total of about $100,000, and the owner's costs at about $90,000. Mobilization and de-mobilization of a 75 ton crane from Yellowknife was estimated to cost $22,000.

A power line to the proposed wind farm area closely following the road would have been 5.5 km long. A straight line from Kee Scarp to the nearest power line could reduce the power line distance to 3.5 km, but to be prudent a straight alignment in two segments generally following the road (one to Kee Scarp and one along Kee Scarp) to the middle of the proposed development site was chosen and 200 meters was added to provide for power collection from the turbines. As the power line is a major cost component of any project, it would be important to examine cost reduction alternatives carefully (the “lowball” estimate cuts this item down aggressively).

Overall the capital costs of a project are a major energy cost driver, so it would be critical for any developer to pay considerable attention to all capital cost components.

Annual costs

The annual costs for a project were looked at as two separate components. First the repayment of the capital costs in mortgage style fixed payments (monthly assumed, but shown as annual in the relevant tables) over 20 years. The interest rates (cost of capital) considered were 8%, 6%, and 4% with 8% representing an approximation of an unsubsidized commercial operation, and 6% and 4% representing different levels of funding assistance. At this time the authors believe that funding assistance would likely be necessary to interest a wind project developer. A project developer would need to determine what the effective cost of capital would be in their circumstances.

The second component is the actual operating and maintenance costs. This would include all overhead, insurance, lease, and tax costs as well as the actual maintenance costs. As it is difficult to estimate these costs, a round figure of $20,000 per turbine per year was taken as being reasonable. This is equivalent to $0.09 per kWh for the estimated production in an annual average wind speed of 6.5 m/s. To examine the sensitivity of projects to this cost, figures of $10,000 and $30,000 per year per turbine were also used in the analyses as low and high operating cost scenarios. Appendix 7 presents the total annual costs of the two project sizes as a function of capital cost, interest rate, and annual operating costs.

Cost of wind energy and economic analyses

Appendices 8 and 9 present the costs of wind energy for the two different project cases of 300 kW and 500 kW as a function of capital costs, interest rates, wind speed, and operating costs.

An unsubsidized 500 kW project (8% interest) installed for the estimated capital cost ($7,044 per kW) and experiencing a medium annual operating cost of $20,000 per year per turbine would produce power at $0.395 per kWh. If capital costs could be reduced to the “lowball” estimate ($5,394 per kW) the cost of power would be reduced to $0.323 per kWh, or if the capital costs increased to a per kW cost of the 300 kW project ($8,820 per kW) the cost of power would increase to $0.472 per kWh.

For an unsubsidized 500 kW project to be economic the cost of diesel fuel would need to be $1.46 per litre, or the wind speed would need to be just over 7.25 m/s with fuel at $1.20 per litre. The project would also be economic if the effective rate of interest was reduced to 4% and the cost of fuel was $1.15 per litre. Alternatively, a proposed ReCWIP type support program the equivalent of $0.15 per kWh would make the project viable at a wind speed of 6.5 m/s and fuel at $1.00 per litre, near to the actual present circumstances.

If the annual operating cost of a 500 kW project could be reduced to $10,000 per turbine and the effective interest rate reduced to 4%, the energy produced with an annual average wind speed of 6.5 m/s would be cheaper than diesel fuel at $1.00 per litre.

The marginal cost of adding of wind capacity was calculated to be about $4,400 per kW (in going from 300 to 500 kW). This marginal capacity, at an unsubsidized interest rate of 8%, an annual operating cost of $20,000 per turbine, and an annual average wind speed of 6.5 m/s, produces power at $0.280 per kWh, equivalent to diesel at $1.04 per litre. This is very close to being competitive in the present circumstances.

These analyses illustrate that while wind energy in Norman Wells is likely still more costly than diesel energy at present, it is not far from being an economic alternative. The analyses underscore the importance of the economies of scale since larger projects produce power at significantly lower costs than smaller ones. Equally important, in the authors' views, is the need to install and operate real projects so that capital costs, operating costs, and turbine performance can be accurately determined for subsequent projects.

To make this and other community wind projects successful a long-term territorial wind development strategy, aided by federal support such as RecWIP, is required. Under such a strategy initial wind projects such as this one will create regional expertise that will become key to developing wind projects in other communities. This will help make wind a local and competitive energy source to diesel-electric generation.

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 this is a reasonable assumption for the 300 kW project, it may a bit optimistic for the 500 kW project for two reasons. First, we have assumed and priced a medium penetration wind-diesel project which requires that the diesel plant continues to operate at some specified minimum load. This will lead to wind energy surpluses as the minimum load that can be served by a wind project is likely to be less than 500 kW. Second, a 500 kW project will produce up to 500 kW under windy conditions, which may be more than the minimum electrical load estimated to be about 500 kW in the community, so any excess will not be useful (until the minimum electrical load is in excess of 500 kW or the surplus power is used to serve industrial load). However, assuming complete diesel displacement is a reasonable first approximation in the circumstances.

Table 1 below outlines the diesel fuel and GHG reductions that would be achieved by a 500 kW project at various annual average wind speeds. The calculations are based on a diesel plant efficiency of 3.7 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. GHG reductions from a 300 kW project would be proportionately lower.

If natural gas were being displaced, the GHG reductions would be reduced to about 63.4% those of the diesel GHG reductions, based on the Inuvik plant efficiency of 3.399 kWh per cubic meter of gas and CO_2 equivalent of 1.9 kg per cubic meter consumed.

Table 1 Annual GHG reductions from a 500 kW wind project by wind speed

Wind speed, m/s	Diesel electricity displaced, kWh	Diesel fuel saved, litres	GHG reductions, kg CO_2 equivalent
5.50	807,975	218,372	617,993
6.00	973,845	263,201	744,859
6.50	1,139,715	308,031	871,728
7.00	1,305,585	352,861	998,597
7.50	1,459,058	394,340	1,115,982

Conclusions

1. Kee Scarp has potential as a wind development site. It is within 5 km of the community and has road access via a 6-km of all-weather road and 1.2 km of 4X4 / ATV trail.
2. Based on local airport and local weather balloon data the wind speed at the altitude of Kee Scarp is projected to be 6.5 m/s ± 0.5 m/s. The local weather balloon data provides a high level of confidence in these projections.
3. The present NTPC diesel plant serves as a back-up plant as more than 99% of the 9,368 MWh annual load (residential, general service, and streetlights) is served by gas generated power purchased from Imperial Oil's 13 MW gas power plant (at a price tied to diesel fuel cost). The gas power plant also serves an industrial load. The peak NTPC load is 1.643 MW, the average load is 1.069 MW (65.1% load factor) and the minimum load is estimated by the authors to be about 500 kW.
4. The available information indicates that the gas supply is limited and may be running low, while the population and NTPC power loads are forecasted to grow. The 2007/8 NTPC load information was used in this study. This project did not consider NTPC's power load growth or industrial loads in the calculations.
5. Costs for 300 kW and 500 kW wind projects were forecasted to be $2.646 million ($8,820 per kW) and $3.522 million ($7,044 per kW) respectively. The incremental increase in capacity between the estimates is about $4,400 per kW. A "lowball" cost estimate for a 500 kW project came in at $2.697 million or $5,394 per kW.
6. Unsubsidized projects of 300 kW and 500 kW in a forecasted wind resource of 6.5 m/s would produce power at $0.472 and $0.395 per kWh respectively. The incremental capacity produces power at about $0.280 per kWh.
7. With a ReCWIP like support of $0.15 per kWh, a 300 kW project would be viable at $1.20 per litre and a 500 kW project would be viable at $1.00 per litre of diesel.

8. At a wind speed of 6.5 m/s a 300 kW project would displace 184,819 litres of diesel fuel and a 500 kW project would displace 308,031 litres of diesel fuel. If gas fired generation were to be displaced the volumes would be 201,185 and 335,309 m3 per annum.
9. GHG reductions on an annual basis are 523,038 kg and 871,728 kg of CO_2 equivalent per year.

Next Steps

1. A wind monitoring tower of 50 or 60 meters should be set up on Kee Scarp on the proposed development site. The wind speed is a critical factor in the economics of a wind power project so it is very important to know accurately what it is.
2. A preliminary review of the land tenure at Kee Scarp should take place to confirm if the site could be available for development.
3. Discussions should be initiated with Imperial Oil and NTPC to determine with greater certainty the situation with respect to gas availability and future power loads.
4. Following confirmation of the wind resource, a detailed feasibility study should be carried out. Particular attention is required to minimize capital costs and identify any available support programs.

Reference:

Maissan, John F., 2008. *Technical Aspects of a Wind Project for Tuktoyaktuk, NWT*. For Aurora Research Institute.

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