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Comments on Power Supply Aspects of the Victor Diamond Project Comprehensive Study, Taking Into Account the August 2004 Re-Evaluation

Philip Raphals
Director

326, Saint-JosephBlvd. East, suite 100
Montreal (Quebec) Canada H2T 1J2
Phone : (514) 849 7900
Fax : (514) 849 6357
sec@helioscentre.org
www.helioscentre.org

1. Introduction

The Helios Centre was asked by the Mushkegowuk Council to review the Victor Diamond Project Comprehensive Study, including the supplemental documents filed in August 2004, with respect to power supply and related issues. Our review was to address both matters of form and of substance. The former category includes issues relating to clarity, comprehensibility, coherence, and the adequacy of the filed documents as a basis for reasoned decision-making. The latter category includes issues relating to the choices that have been made.

2. Clarity and coherence

The documents are generally well written and of clear structure. However, it is very difficult to understand how the conclusions of the technical studies were integrated into higher-level documents.

The most significant problem concerns the choices of options or scenarios studied, which appear to have changed at each step of AMEC's work and, probably for this reason, are not consistent among the various documents. The resulting incoherence is at a minimum irritating and, at times, leads to substantative difficulties.

2.1. The Re-evaluation and TDM 20

The document that summarizes de Beers' current perspective on power supply issues is the *Re-evaluation of Site Access and Power Supply Alternatives* dated August 2004 (henceforth " the Re-evaluation"). In section 2.0, this document announces the study of seven alternatives. (They are misnumbered on page 9 of the Re-evaluation as options 8 to 14.) The seventh alternative is quickly disposed of, leaving six options under active study, as follows:

Alternative	Description
1	Coastal WR, on-site power (diesel), pipeline
2	Coastal WR, diesel, trucked fuel
3	Coastal WR, coastal line to Otter Rapids
4	SWAWR, diesel, trucked fuel
5	SWAWR, coastal line to Otter Rapids
6	SWAWR, line to Kapuskasing

The capital cost and net present value (NPV) of each of these options is summarized in Table 6-1 (p. 62). The power supply costs included in this analysis are apparently derived from Technical Decision Memorandum 20 (TDM 20), filed as Appendix C of the Re-evaluation. the Re-Evaluation presents both capital cost and net present value (NPV) differentials for Alternatives 2 through 6 in relation to the base case (Alternative 1). However, it is not possible to relate these figures to the detailed analysis presented in TDM 20.

First of all, it is important to note that the alternatives presented in the Re-Evaluation differ from the options studied in TDM 20. We have attempted to match them up, as follows:

TDM 20 Options		Re-Evaluation Scenarios	
A1/A2 (preferred)	Coastal line to Otter Rapids (built by HONI/FNEI or DeBeers)	3 (preferred)	Coastal WR, coastal line to Otter Rapids
		5	SWAWR, coastal line to Otter Rapids
B	Direct line to Otter Rapids		
C	Direct line to Kapuskasing	6	SWAWR, line to Kapuskasing
D	Diesel	1	Coastal WR, on-site power (diesel), pipeline
		2	Coastal WR, diesel, trucked fuel
		4	SWAWR, diesel, trucked fuel

Note that of the six options addressed in the TDM, one (option B, a direct line to Otter Rapids) is not addressed at all. The preferred alternative (coastal line to Otter Rapids) is combined both with a coastal winter road (scenario 3) and with the southwest road (scenario 5), whereas Option D (diesel generation), rejected in the TDM, is presented in three distinct scenarios (scenarios 1, 2 and 4) in the Re-Evaluation.

Assuming that the Re-Evaluation builds on the findings of TDM 20, it is not clear why it devotes three distinct scenarios to an option that was rejected in the techno-economic analysis. One possible explanation is that AMEC initially assumed that diesel was still the most cost-effective solution, as it was according to the earlier studies (discussed below, and that the Re-Evaluation was undertaken and largely completed before the preferred grid option (A2) was selected.

Similarly, we were unable to determine the connection, if any, between the capital and NPV costs found in table 6-1 and the data presented in TDM 20. TDM 20 presents capital costs, annual operating costs and present value costs of each of the options considered, with a reasonable degree of detail. But it is impossible to link this information with the summary data presented in the Re-Evaluation.

This is due in large part to the fact that the costs presented in the Re-Evaluation include the costs of developing site access infrastructure. These are presumably detailed in the detailed reports on access, but there is no indication of what figures have been used for each of the two aspects.

A number of other problems and inconsistencies can be noted, including the following:

- Table 6-1 presents net present <u>value</u> differentials, where as TDM 20 presents net present <u>costs</u>. In the former, costs are subtracted from benefits, so higher values are more desirable, where in the latter, costs only are presented, making low values more desirable.

- Table 6-1 gives only the differential from the base case, whereas TDM 20 presents absolute values.

- It is unclear how infrastructure costs for diesel fuel delivery have been handled in TDM 20. Diesel fuel costs are given as lower via the SWAWR than via the coastal route ($0.605 vs. $0.710 per litre). It is unclear if the coastal option is based on pipeline or trucking, or to what extent (if any) infrastructure costs have been included in these costs.

The cost analysis in Table 6-1 suggests that Alternative 2 (Coastal winter road, on-site diesel power generation, winter trucking of fuel from Attawapiskat) is by far the most advantageous. In the analysis (section 6.8), Alternative 3 is selected, based on the non-financial characteristics detailed in Table 6-6.

The reader is left with the clear impression that the Proponent has selected the alternative preferred by the communities, despite its considerable additional costs.

In TDM 20, however, Option A2 (included in Alternative 3) in fact appears to be substantially more cost-effective than Option D (which underlies Alternative 2), from a strictly financial perspective. The preferred alternative selected in the Re-Evaluation is thus in fact the lowest cost alternative, according to the analysis presented in TDM 20.

2.2. TDM 20 and the IMO Preliminary Assessment Report

TDM 20 relies on data from a number of sources, of which the most important is the Preliminary Assessment Report (PAR) prepared by the Independent Market Operator (IMO) in July 2003. This document is filed as Appendix C to TDM 20.

TDM 20 relies on the PAR for its analysis of the transmission system upgrades that would be required to allow the Victor mine to be supplied by grid power rather than on-site generation.

Once again, however, the alternatives and options studied in the PAR are different from those in TDM 20. Specifically:

- The PAR is based on a forecast peak mine load of 27 MW, whereas in TDM 20 the load has been reduced to 19.5 MW.
- The PAR considers a 230-KV option, which is not mentioned in TDM 20.
- The PAR notes the losses in each variant, whereas TDM 20 simply notes that the Victor project is only responsible for those losses which occur beyond its connection at Attawapiskat (and which are negligeable).

In the PAR, high levels of losses above the Attawapiskat connection point are an important factor in leading to the recommended solution. TDM 20 maintains the solution recommended by the PAR, without mentioning defining the role of these losses (which are not the financial responsibility of de Beers) in its decision, and without addressing the consequences of the reduced mine load either on reliability or on losses. These issues are addressed in the following sections.

3. Adequacy

Above and beyond the problems noted above with respect to clarity and coherence, the current documentation does not adequately access the power supply alternatives available to De Beers. It is thus not possible to conclude that the proposed option is optimal.

This analysis will focus on the TDM 20 and its supporting documents, on the assumption that these documents do in fact underlie the cost analysis presented in Table 6-1 of the Re-Evaluation.

3.1. TDM 20

3.1.1. General comments

TDM 20 is essentially a comparison between three grid connection options and on-site diesel generation. The study builds upon (and improves upon) an earlier study, *Review of Power Alternatives for the Victor Diamond Project* (February 2004) (henceforth "the Review"). It corrects many of the weaknesses of the earlier study, which had significantly underestimated the cost of the diesel option. Thus, the cost of diesel fuel delivered to the Victor site has been increased from $0.538/liter in the Review to $0.605 or $0.710 per litre, depending on the transport route — an increase of 12% (for coastal road transport) or 32% (using the South West Alternate Winter Road, or SWAWR).

It appears that this adjustment in the projected cost of diesel is the main reason that the grid options now appear more cost-effective than diesel, as seen in the table found on pages 22-23 of the Re-Evaluation. However, the fact that this level of detail was not presented in the financial analysis in the Review makes it impossible to be certain that other factors did not also play an important role.

While the Re-Evaluation is thus based on updated estimates of diesel costs, it relies on the same Preliminary Assessment Report prepared by the IMO for its analysis of transmission needs. It also adopts without comment or reference the conclusion from the Review that "energy from renewable sources was found to be uneconomic in comparison to diesel generation and grid supply."[1]

3.2. Transmission requirements

As noted above, the Re-Evaluation relies on the Preliminary Assessment Report prepared by the IMO in 2003 — despite the fact that the project load has been decreased to 19 MW from the 27 MW used in the IMO analysis.

To ascertain the consequences, if any, of this change on the need for transmission upgrades, we asked Dr. J.P. Bayne of Bayne Power System Advisors to review these two documents. His report is found in Appendix A. Its conclusions can be summarized as follows:

- Despite the reduced mine load, line C6R (from Otter Rapids to Moosonee) would still be overloaded. Installing a second 115 kV line similar to the existing one (211.6 kcmil) would be sufficient to maintain flows within the line rating and to reduce losses substantially. Using a larger 795 kcmil conductor, as desired by the IMO, would reduce losses even more.

- For the Moosonee to Kashechewan circuit (M3K), however, the reduction of mine load is significant. Even in 2020, when community loads north of Moosonee are expected to reach 13.1 MW, the loadings on the circuit would only be 40.6 MW (including losses), well within the 78 MVA capability of the existing line.

- The PAR's recommendation to double circuit M3K was based largely on the very high level losses (15.1 MW) that would accompany a 27 MW mine load. At mine loads of 19 MW, losses would fall by 33% to approximately 10 MW.

[1] Re-evaluation, p. 1.

As noted in TDM 20, De Beers is only responsible for losses from the grid connection point at Attawapiskat to the Victor project.[2] All other losses are absorbed by the IMO and recovered from all users via the "uplift" charge. Thus, losses on circuits C6R and M3K represent a burden shared among all Ontario electricity users, but not a direct cost to De Beers.

- According to the cost figures presented in TDM 20, eliminating the new line from Moosonee to Kashechwan would result in reducing construction costs by $24.9 million. As De Beers' capital contribution in its Transmission Services Agreement with Hydro One and FNEI wil be approximately equal to the capital cost of the system additions,[3] the project's capital cost would be reduced by this same amount.

- In addition, eliminating this new line would reduce station costs by up to $9 million. As well, there may be additional reductions in voltage control equipment. However, a detailed load flow study would be required to quantify these reductions.

3.3. Renewable energy supply

As noted above, the Re-Evaluation simply repeats the conclusion of the Review that renewable energy is not cost-effective. In the appendix to the Review, entitled "Potential Supplemental Power Sources," AMEC briefly presented the results of a wind power assessment carried out by Zephyr North, which evaluated the average wind speed at 5.2 m/s at the Victor mine site, and at 5.5 m/s at Attawapiskat. It estimates the annual capacity factors at 16% and 18%, respectively.

Based on this analysis, AMEC estimates the cost of wind energy generated at the Victor mine site at $0.25/kWh, or at $0.23/kWh if generated at Attawapiskat. No details are provided for the derivation of these figures.

At our request, Hélimax Energy Inc. of Montreal reviewed the Zephyr North study referred to above, as well as all supporting materials made available by AMEC. Their conclusions can be summarized as follows:

- The wind resource estimate is based on very limited data. Neither Zephyr North nor Hélimax have visited the site. Zephyr North's analysis was based on data collected by a third party, and little information was made available to it concerning the type of equipment used.

- Zephyr North's analysis is well done. However, Hélimax considered appropriate, based on the limited information made available to it, a value of 0.3 meters for the roughness length (Z_0), used to extrapolate wind speeds from the measurement level to hub height. Zephyr North used a value of 0.03m; the file does not indicate on what basis this estimation was made.

- The use of this change in the value of Z_0 results in increasing the estimated wind speed at a height of 65m from 5.2 m/s to 6.0 m/s. At 80m, the average annual wind speed was estimated to be 6.3 m/s.

- These modifications result in much higher energy production for wind power generated at the Victor site than than that estimated by Zephyr North, as follows:

[2] TDM 20, p. 17.
[3] TDM 20, p. 33.

	Zephyr North	Hélimax	
Hub height	**65m**	**65m**	**80m**
Average wind speed (m/s)	5.2	6.0	6.3
Annual capacity factor	16%	21%	23%
Annual energy per 660 kW turbine (MWh)	961	1197[4]	1305[4]

- The financial analysis performed by Hélimax reveals a unit cost for wind-generated energy considerably lower than the $0.25/kWh reported in the Review. Using standard financial parameters and a 20-year project lifespan[5] and assuming a before-tax internal rate of return of zero (because the power is being produced by De Beers for its own use), Hélimax estimated the energy costs as follows, both for the Victor mine site and for a hypothetical site (to be identified) close to the James Bay coast, where the wind regime would be better:

site	hub height	capacity factor	cost ($2006) / kWh
Victor mine	65m	21%	8.5
	80m	23%	8.0
James Bay	65m	26%	7.1
	80m	29%	6.6

3.4. Use of wind energy to meet water pumping requirements

Water pumping makes up a significant portion of the total energy requirements of the Victor mine. Average annual water pumping loads range from 3.4 to 4.3 MW, once the mine is in full operation, with a utilization factor of 85%. Peak loads range up to 4.8 MW.[6]

This load raises a number of interesting possibilities. On the one hand, dewatering does not necessarily need to be continuous, as the underlying need is to evacuate a certain quantity of water per week or month.[7] This raises the possibility of serving the dewatering load via an intermittent energy source, such as wind power.

In reality, there would be considerable efficiencies that could be obtained if wind energy were used to pump water directly, without converting it first to electricity. Wind pumpers exist on an agricultural scale which can make efficient use of winds under 5 m/s, which are inadequate for electric generation. However, we have been unable to identify any manufacturers of wind pumpers that would be suitable for an industrial endeavour like the Victor mine project.

Standard wind turbines, such as the Vestas wind turbines analyzed by Zephyr North and Hélimax, require connection to an electrical grid to function properly. In any event, the fact that De Beers now favours grid power for the Victor project means that this condition will have been met.

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[4] Taking into account 10% overall losses and 5% wake losses.

[5] Which assumes that the energy would be sold after the mine is decommissioned.
[6] TDM 20, Appendix A, Attachment 3.

[7] The dewatering load can be shed for a period of up to two weeks, if necessary. TDM 13 (Appendix A to TDM 20), p. 3.

The fundamental challenge for wind development is the intermittency of the wind resource. Thus, for example, developing wind power to meet the general electric needs of the Victor mine would not reduce the peak loads to be met by grid power, because wind power is not available at all times.

The fact, however, that the Victor project includes a very substantial load which can be served intermettently creates an interesting opportunity for wind development. Assuming that the water pumping equipment were appropriately sized to permit the dewatering needs to be met during the hours when wind energy is available and were switched accordingly[8], the water pumping load would in effect be served locally, and would be removed from project's peak load. The result would be to reduce the peak loads for the transmission system by up to 4.8 MW.

To explore this scenario, we asked Hélimax to evaluate the investments required to build wind turbines sufficient to meet the dewatering load of up to 37 GWh/yr. Their results are summarized in the following table:

	Victor mine site		**James Bay site**	
Hub height (m)	**65**	**80**	**65**	**80**
number of 660 kW wind turbines required	30	28	24	22
Installed wind capacity (MW)	19.8	18.48	15.84	14.52
Net capacity factor	21%	23%	26%	29%
Energy output (GWh/yr)	36.4	37.2	36.1	36.9
Total investment required (2005$ M)	$39.6	$37.7	$31.2	$29.6
O&M expenses ($ M/yr)	$0.6	$0.6	$0.6	$0.6
Avg cost (cents/kWh)	8.5	8.0	7.1	6.6

Thus, considering the hypothesis of a wind farm located at an appropriate site near James Bay (accessible to the existing transmission system) using 80m towers, twenty-two (22) 660kW turbines would be required to produce the 36.9 GWh required annually to meet the dewatering load. The investment cost would be just under $30 million, with annual O&M costs of approximately $600,000.

The table on the following page reproduces the financial analysis of the selected power supply option found on page 27 of TDM 20 (Table 5.2). The table on the subsequent page reproduces this analysis but with the following additional assumptions:

- development of a 14.52 MW wind parc at a James Bay location near the existing transmission system;
- after mine decommissioning, the wind power is sold back to the IMO at the same energy price for the remaining eight years of the wind turbine project life; and
- the proposed line from Moosonee to Kashechwan is not built, as described in section 3.2, above.

The transmission analysis carried out by J.P. Bayne shows that removing the dewatering loads would further reduce losses on circuit M3K (Moosonee to Kashechewan) by an additional 30%, from 10 MW to around 7 MW (i.e. a reduction of over 50% from the levels described in the PAR for a mine load of 27 MW). While this would have no direct financial consequences for de Beers, it would further reduce the burden created by the Victor mine project for Ontario as a whole. Recall that the very high level of

[8] The costs related to these project modifications have not been included in the following analysis, but they are assumed to be relatively minor.

TDM, Table 5.2

	Electricity consumption (GWh)				Capital cost ($M)					Variable costs ($ M)				Total cost
	On-site	Losses	% losses	Total	Lines	Stations	Diesel	Wind	Total	Electricity	Fuel	O&M	Total	($ M)
2005					6,8	3,4			10,2					10,2
2006					30,7	15,3			46					46,0
2007					30,7	15,3	1,2		47,2					47,2
2008	122,3	0,795	0,7%	123,1						9,2	2,1	0,4	11,7	11,7
2009	131,9	0,858	0,7%	132,8						10	2,1	0,4	12,5	12,5
2010	135,1	0,879	0,7%	136,0						10,2	2,1	0,4	12,7	12,7
2011	133,1	0,866	0,7%	134,0						10	2,1	0,4	12,5	12,5
2012	135,9	0,884	0,7%	136,8						10,3	2,1	0,4	12,8	12,8
2013	135,6	0,882	0,7%	136,5						10,2	2,1	0,4	12,7	12,7
2014	135,9	0,884	0,7%	136,8						10,3	2,1	0,4	12,8	12,8
2015	135,9	0,884	0,7%	136,8						10,3	2,1	0,4	12,8	12,8
2016	124,3	0,809	0,7%	125,1						9,4	2,1	0,4	11,9	11,9
2017	134,7	0,877	0,7%	135,6						10,2	2,1	0,4	12,7	12,7
2018	139	0,904	0,7%	139,9						10,5	2,1	0,4	13	13
2019	81,1	0,528	0,7%	81,6						6,1	2,1	0,4	8,6	8,6
2020									1,7					1,7

NPV **$146,19**

WITH WIND GENERATION

	Electricity consumption (GWh)				Capital cost ($M)					Variable costs ($ M)					Total cost
	On-site	Losses	% losses	Total	Lines	Stations	Diesel	Wind	Total	Electricity	Fuel	O&M	Wind O&M	Total	($ M)
2005					4,3	2,65			7,0						7,0
2006					19,5	11,9		14,8	46,3						46,3
2007					19,5	11,9	1,2	14,8	47,5						47,5
2008	85,4	0,795		86,2						9,2	2,1	0,4	0,6	12,3	12,3
2009	95	0,858		95,9						10	2,1	0,4	0,6	13,1	13,1
2010	98,2	0,879		99,1						10,2	2,1	0,4	0,6	13,3	13,3
2011	96,2	0,866		97,1						10	2,1	0,4	0,6	13,1	13,1
2012	99	0,884		99,9						10,3	2,1	0,4	0,6	13,4	13,4
2013	98,7	0,882		99,6						10,2	2,1	0,4	0,6	13,3	13,3
2014	99	0,884		99,9						10,3	2,1	0,4	0,6	13,4	13,4
2015	99	0,884		99,9						10,3	2,1	0,4	0,6	13,4	13,4
2016	87,4	0,809		88,2						9,4	2,1	0,4	0,6	12,5	12,5
2017	97,8	0,877		98,7						10,2	2,1	0,4	0,6	13,3	13,3
2018	102,1	0,904		103,0						10,5	2,1	0,4	0,6	13,6	13,6
2019	44,2	0,528		44,7						6,1	2,1	0,4	0,6	9,2	9,2
2020	-36,9			-36,9					1,7				0,6	0,6	2,3
2021	-36,9			-36,9									0,6	0,6	0,6
2022	-36,9			-36,9									0,6	0,6	0,6
2023	-36,9			-36,9									0,6	0,6	0,6
2024	-36,9			-36,9									0,6	0,6	0,6
2025	-36,9			-36,9									0,6	0,6	0,6
2026	-36,9			-36,9									0,6	0,6	0,6
2027	-36,9			-36,9					2				0,6	0,6	2,6

NPV **$147,44**

losses on this circuit (15.1 MW for a mine load of 27 MW) was the principal reason that the IMO recommended doubling this line. Serving the dewatering loads by local wind generation thus reinforce Bayne's conclusion that the doubling of circuit M3K is no longer necessary.

The results show that the present value cost of the two scenarios is pratically identical ($146,19 million vs. $147.44 million). Furthermore, the capital costs of the two scenarios are also very similar. In other words, using $29 million to build wind generation rather than the M3K transmission upgrade would, it appears, result in equivalent service to the mine.[9]

It is important to note that this analysis does not take into account potential incentives for wind development from the federal or provincial governments. The federal government currently offers a wind energy production credit of 1¢/kWh. On the provincial side, the Ontario government is currently carrying out a call for tenders for renewable energy, and similar initiatives are expected in the coming years. It is to be expected that a wind development such as the one described here would be eligible for both of these support mechanisms, further reducing the financial costs to De Beers.

It should also be noted that this solution would have considerable benefits for the Ontario public as a whole. It would reduce the mine load to be borne by the power grid by 36 GWh/yr, at a time when meeting future energy needs is a major challenge for the Ontario power system. It would reduce losses on the M3K circuit by several megawatts, a burden which would otherwise be borne by all Ontario power users. And of course, it would substantially reduce greenhouse gas emissions, assuming that the mines loads will ultimately be served by thermal power purchased elsewhere in Ontario.

[9] The reliability benefit resulting from having two distinct circuits on separate poles between Moosonee and Kashechewan (TDM 20, p. 24) would be lost. However, the existing grid supply to Attawapiskat has been very reliable and, since the existing lines are new, should remain so (TDM 20, p. 23).

J.P. Bayne, Ph.D., P.Eng.

347Janene Court
Mississauga, Ont.
L5A 3Z2 CANADA

Power System
BAYNE
Advisors

Phone & Fax (905) 270-0428
E-mail baynejp@pathcom.com

POWER SUPPLY TO THE VICTOR MINE

Introduction

The Victor diamond mine is located approximately 90 km west of the village of Attawapiskat on the western shore of Hudson Bay. Initially, the mine was expected to have a load of 27 MW at 0.9 power factor[1] or 30 MVA. This was subsequently reduced to 19 MW[2]. It is scheduled to remain in service until 2019.

The IMO produced a Preliminary Assessment Report in July 2003. It considered a number of different options for the power supply to the mine (for loads then estimated at 27 MW) and defined the facilities required to make each option viable.

A Technical Decision Memorandum was prepared by AMEC in August 2004. It considered a reduced number of alternatives and concluded that supply from the grid was the preferred option. The AMEC document does not appear to have taken into account the impact of reducing loads from 27 MW to 19 MW and the resulting decrease in electrical power losses and hence on the need for new transmission facilities.

This document examines Option A which is Grid Supply via a reinforced HONI/FNEI system[3]. It is shown diagrammatically on Figure 3.1 in the AMEC report. The option will also include six 1.3 MW diesel units which will be available for emergency and backup. They are not assumed to be running for day–to-day operation. Option A is divided into A1 and A2 for the costing. A1 is based on HONI costs and A2 is based on Powertel costs.

Options B and C involve transmission lines directly to the Victor mine from the HONI stations at Otter Rapids and Kapuskasing. The reduced load will not reduce the amount of facilities required so they are not considered any further. Option D was a complete diesel supply with no grid connection. It was discarded on the basis of overall costs[4].

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[1] PAR page 1
[2] AMEC page 1
[3] AMEC page 10
[4] AMEC page 39

Transmission Line Characteristics

The existing transmission lines are strung with 211 kcmil conductor. The section from Otter Rapids to Moosonee is sagged for a maximum conductor temperature of 60°C. Its rating at 30°C is 57 MVA[5]. The section from Moosonee to Attawapiskat has a rating of 78 MVA at 25 °C[6].

The surge impedance loading is the line load where the voltage drop due to the inductive impedance cancels the voltage rise due to the capacitive impedance. At this loading the need for voltage control equipment is minimized. Below this loading voltage control equipment (reactors) will be required to keep the voltage down to an acceptable level. Above it voltage control equipment (capacitors) will be required to raise the voltage. On a 115 kV line, the surge impedance loading is between 33 MVA and 35 MVA[7].

As the current passes through the lines, the wires heat up. This consumes megawatts which must be supplied by a source of power somewhere on the system. By putting a line in parallel with an existing one the current in each will be half the original amount. As thermal losses increase with the square of the current flow, the losses in each line will only be one quarter of the losses with only one line. The total losses in the two lines will be half the losses with the original line. If the new line has a larger cross section than the original line, the losses will be further reduced.

Otter Rapids to Moosonee Circuit C6R

Tables 1.1 and 1.2 in the PAR show that C6R will be overloaded with 18 MW at Victor in 2006 and 16 MW in 2010. The corresponding losses on C6R are 11.5 MW and 11.7 MW. By installing a second circuit from Otter Rapids to Moosonee the flow on each circuit will be reduced well below the line rating and the losses in that section with a 20 MW Victor load will be reduced by 7 to 10 MW. If a larger 795 kcmil conductor is used, as desired by the IMO[8], the reduction in losses will be even greater. The IMO study showed that, even with a 24 MW mine load, the 2020 losses on this line would be just 3.1 MW[9].

The line and station costs associated with this line will be the same as in the reports.

Moosonee to Kashechewan

The loads north of Moosonee are expected to be 13.1 MW in 2020 when the mine ceases operation[10]. The mine load is now expected to be 19 MW[11], including a water pumping load of about 5 MW at peak, and 3.5 to 4.0 MW average[12].

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[5] PAR page 2
[6] PAR page 3
[7] Westinghouse T&D Reference Book page 280
[8] AMEC p. 16
[9] PAR Table 4, p. 21
[10] PAR page 5
[11] AMEC page 1

The losses north of Moosonee with the existing facilities, 2006 loads (6.7 MW north of Moosonee[13]) and a 20 MW mine load would be 9 MW[14]. With a 14 MW mine load, they would be reduced to 5.3 MW[15].

The projected 2020 loads north of Moosonee are 13.1 MW. With a mine load of 19 MW, and losses north of Moosonee of about 8.5 MW this would make a total of 40.6 MW on circuit M3K[16]. This is well within the 78 MVA capability of the existing 115 kV FNEI line from New Moosonee DS to Kashechewan.

With a mine load of 24 MW, however, losses on circuit M3K in 2020 would reach 15.1 MW[17]. At mine loads of 19 MW, these losses would be reduced to approximately 10 MW. An accurate assessment would require a load flow study.

Other Voltage Control Equipment

It is possible that the requirement for voltage control equipment at the stations may be different using only the existing transmission line north of Moosonee. Detailed load flow analysis would be required to determine whether more or less equipment would be required. The difference in costs would likely be small.

Residual Value

The new Otter Rapids to Moosonee line will continue to provide savings in losses for long after the mine ceases operation. In the 1970s or 1980s a mine mouth lignite plant was planned for the Onakawana area which is about half way from Otter Rapids to Moosonee. Should that station be built in the future, the 115 kV lines could carry out some of the power. With 795 kcmil conductors, this line could carry over 200 MW.

Decommissioning Costs

The decommissioning costs[18] are much less for the option A as they are limited to the Victor to Attawapiskat line and the facilities at Victor.

Use of wind powered generation

Wind powered generators located at Victor or on James Bay near Attawapiskat would back off flows on the M3K line. The Attawapiskat load is forecast to grow from 2.6 MW

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[12] AMEC, App. A, Attachment 3
[13] PAR page 5
[14] PAR Table 1.1 page 13
[15] Ibid.
[16] PAR Table 1.1 page 13
[17] PAR Table 4, p. 21
[18] AMEC page 21

in 2006 to 8.4 MW in 2030.[19] When the mine is in operation an additional 19 MW will flow in to Attawapiskat for the mine. The losses on the M3K line will be reduced by adding generation at Attawapiskat. Since losses are proportional to the square of the current flow, any reduction in load will substantially reduce the losses. Thus, if the 2020 losses for a 19 MW mine load would be 10 MW, as noted above, they would fall to approximately 7 MW if 4 MW of the mine's load was supplied locally. An accurate assessment would require a load flow study.

<u>Potential reduction in capital cost</u>

If the new line proposed in Option A from Moosonee to Kashechewan were not required, line construction costs of $24.9 million could be avoided[20].

There would also be some reduction in the station equipment associated directly with the new line. The following is based on a comparison of Diagrams 1 and 14 in the PAR :

Station	Equipment saved	Financial Savings
New Moosonee TS	1circuit breaker	$1.5-$2M
Kashechewan	2 circuit breakers + 1 reactor	$5-$7M

The costs are based on section 7 in the PAR

The result would thus be to reduce the capital costs for Option A2 by 35%, from $105.9 million to $66 million. There may be additional reductions in the amount of voltage control equipment, but these would be much smaller and would require an extensive load flow study.

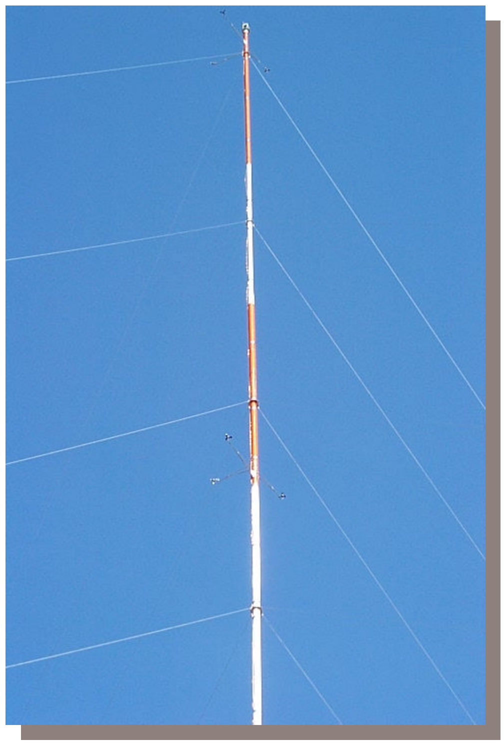
[19] PAR page 5
[20] AMEC page 18

Dr. Jim Bayne is an independent consultant providing advice on high voltage transmission systems in Ontario and neighbouring power systems. He contributed to the discussions on the design of the electric market in Ontario and the preparation of a transmission tariff for the Volta River Authority in Ghana. He is also acting as an expert witness in an American Arbitration proceeding. He has carried out foreign assignments in Ghana, China and the Philippines. He was a member of the Hydro Quebec advisory committee on Special Protection Systems which reviewed the improvements to upgrade the stability of the Hydro Quebec system.

He retired from Ontario Hydro in 1993 after spending 16 years in the Transmission System Planning Department and 6 years in the Electrical Research Department. In System Planning he supervised groups of engineers involved with the planning of the High Voltage Transmission System in Ontario and in carrying out studies with neighbouring systems in Quebec and the United States. He also explained transmission systems at public meetings and public hearings. At the Research Division he was involved with the mathematical modelling of power apparatus for use in power system analysis.

Prior to joining Ontario Hydro he received his Ph.D. and M.Sc. degrees from the University of Manchester and worked for Westinghouse in Canada and General Electric in the USA. He received his undergraduate degree from Queen's University in 1964.

DUE DILIGENCE FOR VICTOR DIAMOND SITE PROJECT



Client:

HÉLIOS CENTRE
326 St. Joseph Boulevard East
Suite 100
Montreal, Quebec
H2T 1J2
www.centrehelios.org

Prepared By:

HÉLIMAX ENERGY INC.
4101 Molson Street, Suite 100
Montreal, Quebec
H1Y 3L1
Phone: 514-272-2175
Fax: 514-272-0410
www.helimax.com

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INTRODUCTION

The Victor Diamond mine site has been selected by De Beers Canada for the construction and operation of its Victor Diamond Project. AMEC, an international engineering services company, has been mandated to manage the project including the construction of a power plant to supply energy to the mine. During full operation of the mine an electrical peak load of up to 20 MW is expected. Following multiple trade-off studies comparing different types of solutions in order to provide the installations with reliable and cost-effective electric power, AMEC originally established pure on-site diesel generation as the most feasible option. Recently one of the options investigated and dismissed was the integration of wind energy to power the mine in order to reduce the impact due to harmful emissions from diesel combustion. A study of the wind potential at the Victor Site was done by Zephyr North (ZN) in March 2003 to allow AMEC to analyse the economic feasibility of implementing a wind-diesel hybrid system. This report will review the results obtained by ZN in order to assess the validity of the analysis.

Only limited access to documentation was permitted at the AMEC offices in Oakville, Ontario. Documents were reviewed on Thursday, May 27th, 2004 in order to allow the analysis of the case study. All the information concerning the AMEC and ZN reports was gathered and noted at these offices. Since no photocopies were allowed, only limited information was noted as time permitted.

Based on the limited information, this document will focus on the estimation of the wind resource at the Victor Diamond site. The annual average wind speed will be determined and a calculation of the expected annual wind energy yield output of a typical wind farm will be evaluated. An alternative solution will be suggested in order to improve wind energy production by selecting a different site with higher wind speeds. Finally, a typical financial analysis for grid-connected wind farm will be performed for eight (8) different scenarios.

1 SITE WIND RESOURCE ESTIMATION

In order to draw a figure of the wind resource available at the Victor Diamond Project site, several sources of information have been inspected and led to the following summary of information.

1.1 DATA COLLECTED ON SITE

1.1.1 Source of data

According to ZN, wind speed has been monitored on site by means of a 10 meter meteorological tower between 1999 and March 2003. The data collected at the site was analysed by ZN and summarized in the report entitled "*Wind Resource Assessment for Victor Diamond Mine*" dated March 3rd, 2003. It seemed that limited information about the tower and its monitoring system was made available to produce the above mentioned document. As no report indicates the details of the instrument specifications of the monitoring tower it is not possible to validate the assumptions made by ZN in its analysis. However, the assumptions seem reasonable. According to the report, ZN has verified the data for completeness and icing events. The hourly data was processed using standard procedures by ZN and extrapolated to 65 m above ground level (agl) with a roughness length of z_0=0.03m.

1.1.2 Results

Table 1-1 below shows processed meteorological data (i.e. ambient temperature, wind speed at 10 m agl, wind direction and derived wind energy output) according to the ZN report.

The columns in grey represent the monthly wind speed data calculated using the formulas presented in the ZN report in order to retrieve the original measured monthly averages at 10m as they were not presented in the report[1].

[1] As explained in Appendix A of the ZN report, the vertical extrapolation of wind speed from one level to another is obtained using the following equation:

$$U_{extrapolated} = U_{measured}\left(\frac{\ln\left(\frac{z_{measured}}{z_0}\right)}{\ln\left(\frac{z_{extrapolated}}{z_0}\right)}\right)$$

Where $U_{measured}$ and $U_{extrapolated}$ are measured and extrapolated average wind speeds respectively at $z_{measured}$ and $z_{extrapolated}$ heights. Z_0 is the roughness length of the environment of the wind tower.

Table 1-1 Meteorological Variables from the ZN report

ZN Numbers						Calculated data
Period	Temperature (deg C)	Wind Speed at 65m (m/s)	Wind Direction (deg)	Turbine Output (MWh)	recovery rate	Wind Speed at 10m using Z_0=0.03 (m/s)
January	-20.4	4.5	284	65.1	100	3.4
Febuary	-21.1	4.8	322	70.1	100	3.6
March	-13.6	5.1	303	87.5	96	3.9
April	-1.8	5.2	39	78.7	100	3.9
May	8.6	5.6	64	96.7	100	4.2
June	11.3	5.6	336	85.7	100	4.2
July	15.8	5.1	332	70.9	100	3.9
August	15.6	5.3	275	77.9	100	4.0
September	8.6	5.3	296	77.1	100	4.0
October	3	5.5	260	92.6	100	4.2
November	3.6	4.8	275	59.1	100	3.6
December	-15.6	5.5	307	101.2	100	4.2
Yearly	-0.5	5.2	311	962.6	99.7	3.9

The yearly average wind speed calculated at 10 m is the same value as the average wind speed given by an earlier study done by AMEC. The June 28th, 2002 study entitled "*Wind Power*" states a measured yearly average wind speed at 10 m agl of 3.9 m/s. It is also mentioned in the ZN report that the Weibull shape factor for the Victor Diamond site is k= 2.1 at 10m agl.

1.1.3 Validity of the data

According to the ZN report, the measured data was quality controlled according to the industry standards based on the limited information made available to ZN. However, the final result should not be considered as a highly accurate depiction of the site. Many factors considerably reduce the precision of the values obtained by Hélimax from the reports reviewed.

Firstly, ZN had very little information on the type of tower, instruments and data acquisition system used. Estimates from the photos of the tower were necessary to determine the anemometer make and model.

Secondly, assumptions as to the site layout were necessary because ZN did not visit the site. Values for roughness were made from directional photos of the tower. Furthermore, wind data was measured at 10m agl, and a large uncertainty must be included in the extrapolation made for wind speed prediction at typical hub heights. According to the ZN report a comparison of the wind speeds at the Victor Diamond site to data from a tower operated by ZN at Attawapiskat (around 100 km east of the Victor Diamond site) showed similar values. It appears, from the scarce information about the tower and the monitoring system used for comparison, that it was surrounded by buildings and is a lattice style tower. Data for this tower was not considered of interest for the analysis at the Victor Diamond site.

These reasons mentioned above increase the uncertainty of the data. It should then be considered with caution for wind resource analysis and taken as a rough indication of the wind potential at the Victor Diamond site.

1.2 ENVIRONMENT CANADA DATA

Environment Canada operates 10 m wind monitoring towers and collects meteorological data that can be used as a primary indication of wind speeds at a specific site. If an Environment Canada station is close to the site of interest and the environing features of the site under study are similar to those of the mast, wind speeds can be considered similar. Many of the Environment Canada meteorological stations surrounding the Victor Diamond site were inspected and it was revealed that none of the towers had significant data that could be used. The closest meteorological stations with reliable data available are the Peawanuck and Moosonee towers. They are both at about 300 km from the site of interest and in different geographical settings. Figure 1.1 below shows a map localizing the Victor Diamond project site and the Environment Canada meteorological stations in the surrounding area.

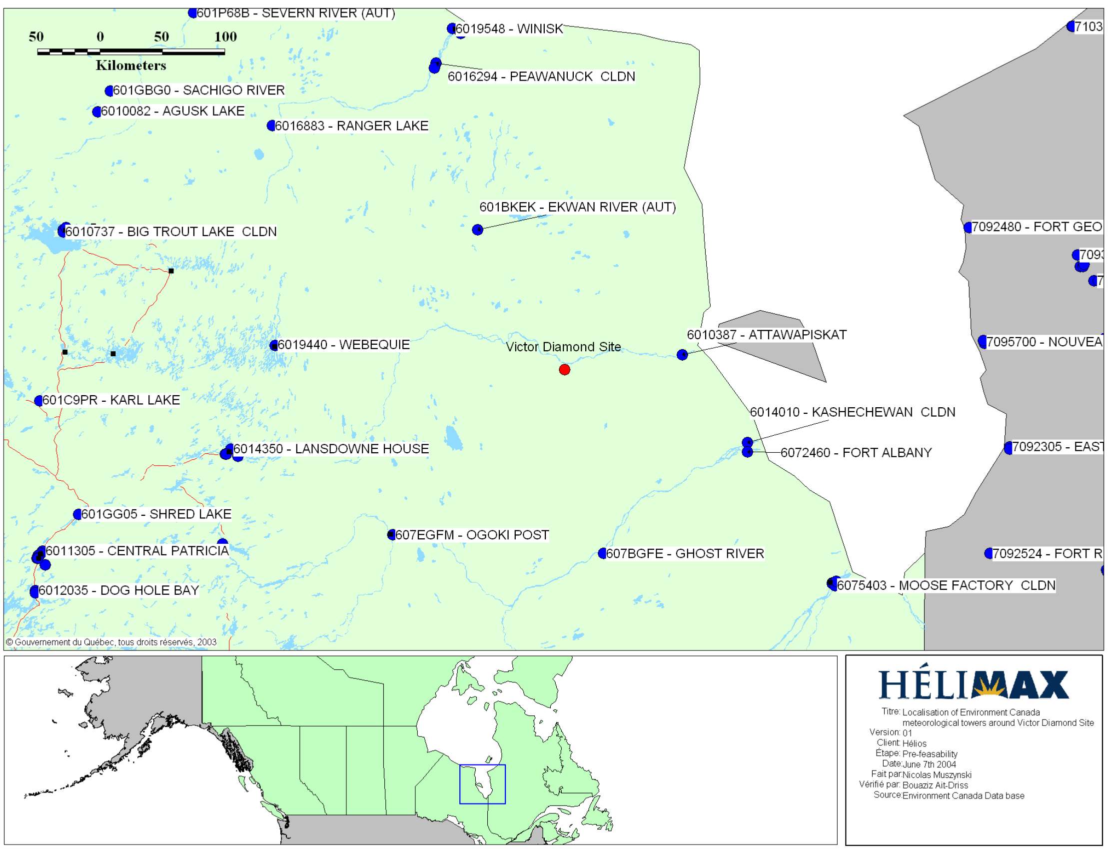

Figure 1.1 : Map of Environment Canada Towers in the Victor Diamond Project Area

The Ekwan River, Attawapiskat and Webequie stations do not have usable wind data. As explained, the location of the stations mentioned above would not be of relevance to the assessment of the Victor Diamond Site potential. Therefore, it was decided to not use any of the data from the stations mentioned above.

1.3 OTHER SOURCES OF DATA

1.3.1 Source of Data

One of the sources of data considered for wind speed estimation at the Victor Diamond site is the mesoscale wind map produced by Environment Canada for the region[2]. The mesoscale wind map gives a rough estimate of the wind speeds and is intended for general site prospection. It has been based on a 30 kilometre resolution. The wind map is depicted in Figure 1.2. As we can see wind speeds at the Victor Diamond site are in the 5.6 to 6.4 m/s wind class. The mast data extrapolated from 10 meters to 50 meters with a roughness length of 0.3 meters gives a wind speed of 5.69 m/s. This value is within the lower limit of this range.

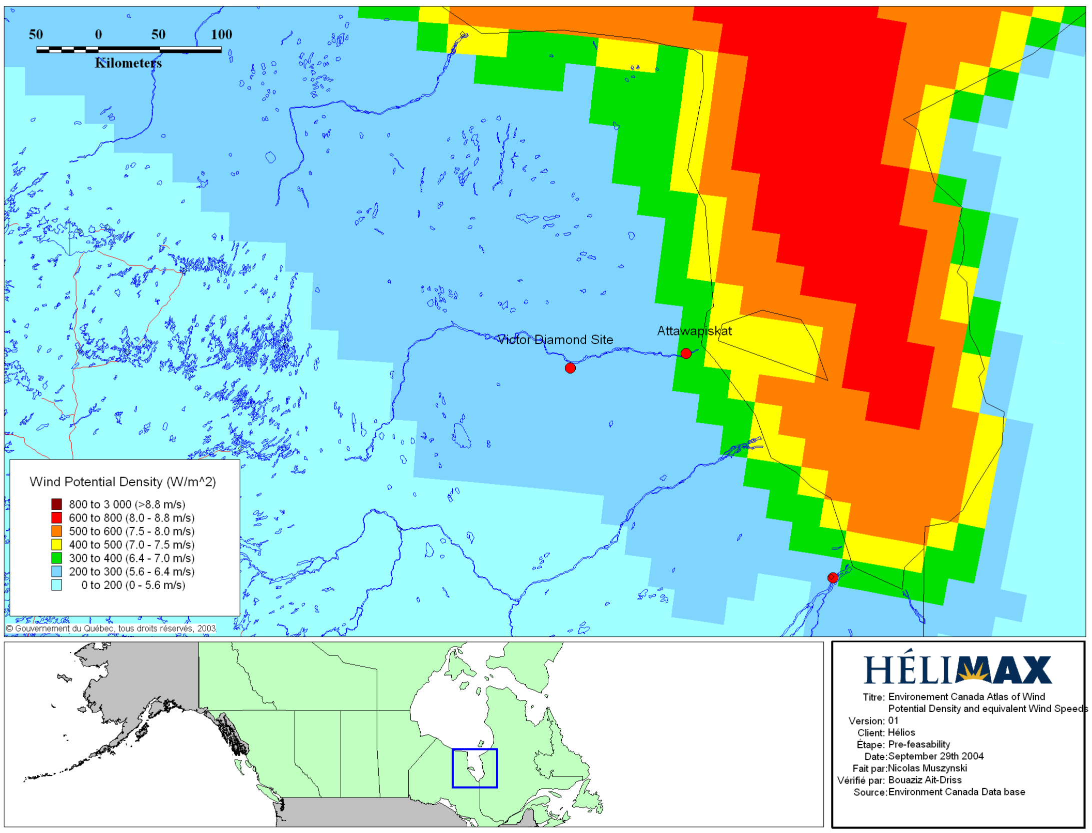

Figure 1.2: Mesoscale Wind Map of James Bay at 50m agl

1.3.2 Validity of the Data

This source of data cannot be used to predict the exact wind speeds. The mesoscale simulation gives a good idea of the areas to investigate for wind energy development and where further measurement campaigns should be performed. The simulation is included in the analysis as it provides a tool for validation to a certain extent of the data published in the ZN report. As can be seen, the mesoscale simulation at the Victor Diamond site has wind speeds similar to the observations at the site. This simulation can be taken as a good indication of the wind speeds at 50 m agl relative to the observations performed by AMEC.

[2] Environment Canada, MC2 WEST model, 50m agl Atlas of Canada (1996-2000)

1.4 ESTIMATION OF THE WIND ENERGY YIELD

Hélimax used the data recovered at 10 m agl from the information published in the ZN report. The Vestas V47 – 660 kW has been used for energy yield estimation for a wind farm of a typical configuration at the Victor Diamond site. It has been assumed that the projected site is typical of the region based on a general description of the area and it is considered that no special topographic features are present at site.

Two hub heights have been considered (65 m and 80 m agl) for energy yield estimation using the same wind turbine type. The extrapolation of wind speeds at hub height were performed using a roughness length of z_0=0.3m[3] (ZN uses a value of 0.03m). Roughness length determines wind shear and influences extrapolated wind speed. This value is estimated based on photographs of the general area (not of the specified site), a map of land cover for the Victor Diamond site and according to the classification published in the European Wind Atlas. This value considers a partial tree cover of small trees (trees of about 8 meters according to the reported information in the ZN report). Photographs and a map of the area were obtained from the Victor Diamond Environmental Assessment Comprehensive Study presented on the De Beers Canada Web site[4] and are included in Appendix 2. It should be noted that without a site visit and photographs of the domain of the project, it is difficult to evaluate the roughness length of the site. Vertical extrapolation of wind speed from the 10 meter level to typical hub heights using estimated roughness length introduces significant uncertainty.

It should also be noted that no climatological adjustment has been performed on the data since the original detailed data was not available.

Table 1-2 below shows the results of the estimated average wind speeds at 65m and 80m agl. The reference energy yield represents the energy production of the wind turbine if it is sited at the mast location. The Weibull wind speed distribution shape factor of k=2.1 is used as given in the ZN report. The commercial power curve for the Vestas V47 turbine is used at an air density of 1.27 kg/m^3 as obtained from the manufacturer. The higher density power curve was used to include the impact of temperature on the wind turbine power curve as lower temperatures increase energy yield.

The net energy yield is the estimated energy at the metering point of the wind farm. It includes a typical 10 % overall loss such as icing losses, electrical losses, blade soiling and turbine availability. It includes also a typical 5% loss of wake effect. The latter is due to the shading of turbines on each other.

The net capacity factor is then calculated. This parameter indicates the performance of the wind farm in the site based on the wind turbine efficiency and on the quality of the wind resource of the site. It is defined as the ratio of the annual energy yield over the installed capacity of the wind farm times the number of hours in a year (8760).

[3] Table of Roughness Length, European Wind Atlas, Risoe National Laboratory, Roskilde, Danemark
[4] http://www.debeerscanada.com/files_2/victor_project/victor_ea-report-2004.html.

Table 1-2 Summary of the Energy Yield Calculation

Period	Wind Speed (m/s) at 10m	Wind Speed (m/s) at 65m with Z0=0.3	Wind Speed (m/s) at 80m with Z0=0.3	Reference Energy yield at 65 m (MWh)	Reference Energy yield at 80 m (MWh)	Net Energy yield at 65 m (MWh) (10% overall losses and 5 % wake losses)	Net Energy yield at 80 m (MWh) (10% overall losses and 5 % wake losses)	Net Capacity factor at 65 m	Net Capacity factor at 80 m
January	3.4	5.2	5.4	82	91	70	78	14%	16%
February	3.6	5.6	5.8	88	97	75	83	17%	19%
March	3.9	5.9	6.1	114	124	97	106	20%	22%
April	3.9	6.0	6.3	115	126	99	108	21%	23%
May	4.2	6.5	6.7	141	152	120	130	24%	27%
June	4.2	6.5	6.7	136	147	116	126	24%	27%
July	3.9	5.9	6.1	114	124	97	106	20%	22%
August	4.0	6.1	6.4	125	136	106	116	22%	24%
September	4.0	6.1	6.4	120	131	103	112	22%	24%
October	4.2	6.4	6.6	135	147	116	125	24%	26%
November	3.6	5.6	5.8	95	104	81	89	17%	19%
December	4.2	6.4	6.6	135	147	116	125	24%	26%
Yearly	3.9	6.0	6.3	1400	1526	1197	1305	21%	23%

2 ALTERNATIVE SCENARIO

Wind resource generally increases as proximity to the coast is increased. As one of the possible scenarios called for the construction of a transmission line from Attawapiskat to the Victor Diamond site, a wind farm on the coast along the existing transmission line was considered.

Using output from the mesoscale model simulation wind speed has been estimated at the Attawapiskat area along the coast relative to the data from the Victor Diamond wind mast. Judging from the wind map (50m agl) given in Figure 1.2, the wind speed for the Victor Diamond site seems to be approximately 5.6m/s.

Extrapolating this wind speed to 65 and 80 m agl yields the average wind speeds depicted in the table below. All wind speeds are extrapolated based on the roughness length values presented in the last column.

Table 2-1: Resume of wind speeds from different sources

Height agl	*50m*	*65m*	*80m*	*Zo (m)*
Atlas EC on-site (m/s)	5.60	5.89	6.11	0.3
Helimax extrapolation of ZN data (m/s)	5.69	6.0	6.3	0.3
Atlas EC Near-Shore (m/s)	6.4	6.73	6.99	0.3
ZN report data (m/s)	5.0	5.2	5.3	0.03

As expected, EC Atlas map suggests that wind speeds will increase at the areas closer to the shore. A relative increase from 5.6 m/s to 6.4 m/s at 50 m agl would cause an increase in the net capacity factor for 65 m agl from 21% to 26% and an increase from 23% to 29% for 80 m agl. This is assuming overall losses of 10% and 5% losses for wake effects.

3 FINANCIAL AND SENSITIVITY ANALYSIS

3.1 METHODOLOGY

This section will present the results from a generic pre-tax financial and sensitivity analysis for four (4) different scenarios based on the energy analyses above. The analysis assumes a grid-connected wind energy project to be implemented in the context of Victor mine's operations, either next to the mine or at an alternative windier site located on the shores of James Bay.

The analysis was carried out for the eight (8) predetermined scenarios as follow:

<u>At Victor mine site:</u>

- Scenario 1.1:
  19.8 MW installed capacity with 65 m towers and project lifespan of 20 years.

- Scenario 1.2:
  19.8 MW installed capacity with 65 m towers and project lifespan of 12 years.

- Scenario 2.1:
  18.5 MW installed capacity with 80 m towers and project lifespan of 20 years.

- Scenario 2.2:
  18.5 MW installed capacity with 80 m towers and project lifespan of 12 years.

<u>At James Bay site:</u>

- Scenario 3.1:
  15.84 MW installed capacity with 65 m towers and project lifespan of 20 years.

- Scenario 3.2:
  15.84 MW installed capacity with 65 m towers and project lifespan of 12 years.

- Scenario 4.1:
  14.52 MW installed capacity with 80 m towers and project lifespan of 20 years.

- Scenario 4.2:
  14.52 MW installed capacity with 80 m towers and project lifespan of 12 years.

A set of generic and project specific parameters, values, and assumptions were determined for these scenarios, as shown in Table 3-1 of section 3.2.

Each of these analyses were performed in order to find the required electricity selling price per kWh in order for the project to produce a before tax Internal Rate of Return (IRR) of 0%. This means that all eight (8) scenarios were assessed and calculated. Results are summarized in Table 1-1 of section 3.3.

Helimax then produced a full sensitivity analysis of the price per kWh for the most profitable scenario on each of the two locations, while varying the net energy yield from plus to minus 5%, 10% and 20%. Results are summarized in Table 3-3 and Table 3-4 of section 3.3.

3.2 PARAMETERS, VALUES, AND ASSUMPTIONS

The following table shows the parameters, values, and assumptions that Helimax used in its financial and sensitivity analyses.

Table 3-1: Parameters, values and assumptions used for the financial and sensitivity analysis

Parameter	*Value for 1.1 and 1.2*	*Value for 2.1 and 2.2*	*Value for 3.1 and 3.2*	*Value for 4.1 and 4.2*	*Unit*	*Source of data*
Site location	Victor mine	Victor mine	James Bay	James Bay	MW	Helimax
Project installed capacity	19.80	18.48	15.84	14.52	MW	Helimax
Number of wind turbines	30	28	24	22	Units	Helimax
Turbine hub height	65	80	65	80	m	Helimax
Turbine rating	660	660	660	660	kW	Helimax
Net Capacity Factor (CF)	21	23	26	29	%	Helimax
Net Energy Output	36,424	37,233	36,077	36,886	MWh/y	Helimax
Project life	20 and 12	20 and 12	20 and 12	20 and 12	Years	Helios
Start of commercial operation	2006	2006	2006	2006		Helimax
Adjustment factor- Year 1	75	75	75	75	%	Helimax
Total project investment Amount ($CND)	39,600,000	37,699,200	31,680,000	29,620,800	$ 2005	Helimax
Equity Percentage of total project investment Amount ($CND)	30 11,880,000	30 11,309,760	30 9,504,000	30 8,886,240	% $ 2005	Helimax
Debt Percentage of total project investment Amount ($CND)	70 27,720,000	70 26,389,440	70 22,176,000	70 20,734,560	% $ 2005	Helimax
Debt						Helimax
- Interest rate	8	8	8	8	%	Helimax
- Term	18 and 12	18 and 12	18 and 12	18 and 12	Years	Helimax
- Number of payments per year	4	4	4	4		Helimax
Operation and Maintenance (O & M) expenses ($CND)	1.5	1.5	1.5	1.5	¢ 2006 / kWh	Helimax
Inflation rate for Operation and Maintenance (O & M) expenses	2.0	2.0	2.0	2.0	%	Helimax
Indexation rate of electricity selling rate	2.0	2.0	2.0	2.0	%	Helimax
Property Tax Rate	3.0	3.0	3.0	3.0	% of total incomes	Helimax
WPPI (over the first 10 years of operation)	1.0	1,0	1.0	1,0	¢ 2006 / kWh	Helimax

3.3 RESULTS OF THE FINANCIAL AND SENSITIVITY ANALYSIS

Table 3-2: Results of the financial analysis

Scenario	Site	Hub height	Project lifespan	Required selling price per kWh ($2006) in order for the project to produce 0% BTIRR
Scenario 1.1	Victor mine	65 m	20 years	8.5
Scenario 1.2	Victor mine	65 m	12 years	12.7
Scenario 2.1	Victor mine	80 m	20 years	8.0
Scenario 2.2	Victor mine	80 m	12 years	11.8
Scenario 3.1	James Bay	65 m	20 years	7.1
Scenario 3.2	James Bay	65 m	12 years	10.4
Scenario 4.1	James Bay	80 m	20 years	6.6
Scenario 4.2	James Bay	80 m	12 years	9.5

Table 3-3: Results of the sensitivity analysis for the most profitable scenario at Victor mine site

Energy Yield Variation on scenario 2.1 (Victor mine, 80 m, 20 years)	**Required selling price per kWh ($2006) in order for the project to produce 0% BTIRR**
29,786 MWh/year (-20%)	9.7
33,510 MWh/year (-10%)	8.8
35,371 MWh/year (-5%)	8.4
37,233 MWh/year (baseline)	**8.0**
39,095 MWh/year (+5%)	7.7
40,956 MWh/year (+10%)	7.4
44,680 MWh/year (+20%)	6.9

Table 3-4: Results of the sensitivity analysis for the most profitable scenario at James Bay site

Energy Yield Variation on scenario 4.1 (James Bay, 80 m, 20 years)	**Required selling price per kWh ($2006) in order for the project to produce 0% BTIRR**
29,509 MWh/year (-20%)	8.0
33,197 MWh/year (-10%)	7.2
35,042 MWh/year (-5%)	6.9
36,886 MWh/year (baseline)	**6.6**
38,730 MWh/year (+5%)	6.3
40,575 MWh/year (+10%)	6.1
44,263 MWh/year (+20%)	5.7

4 CONCLUSION

The purpose of this document was to attempt the assessment of the wind resource at the Victor Diamond site for a potential wind energy project development. The suggestion of a site with better wind resource was also suggested. Finally, a financial analysis was performed to evaluate the base scenario, as well as an alternative scenario.

Very limited data was made available to undertake the analysis. Access to the information was restricted to a consultation of the documents at the AMEC offices.

The report entitled "*Wind Resource Assessment for Victor Diamond Mine*" dated March 3rd, 2003 was used as the source of wind data collected on site by means of a 10 m meteorological tower owned by AMEC. The wind mast was operational between 1999 and March 2003, however, no information has been made available for the analysis, such as instrument configuration, type and specifications.

The estimated energy yield presented in this analysis should be considered with care as many factors increase uncertainty on the final result of the energy yield predictions since the latter is very sensitive to wind speed (approximately proportional to the square of the wind speed).

Among the factors that may add uncertainty to the final predictions are:

- Quality of the original data and the quality control procedure that has been performed on the data;
- Climatological adjustment of the data observed (no long term adjustment has been performed);
- Vertical extrapolation of wind speeds to hub height from measurements at 10 m agl;
- Wind farm configuration and siting relative to the surrounding environment and future obstacles planned in the project (new constructions and buildings).

The annual net capacity factors are estimated at 65 m agl and 80 m agl are 21% and 23% respectively for a wind farm at the Victor Diamond site. A wind farm sited on the shores of the James Bay would see an increased capacity factor of 26% and 29% for the 65m and 80m levels.

It was assumed that the wind projects (at the Victor Diamond site or near the James Bay shore) will be connected to the utility grid and no restrictions will be made on the flow of energy between the wind farm and the utility grid.

These capacity factors may be considered as low when considered for a commercial grid connected wind project. Nonetheless, these figures can raise an interest if studied in the context of a grid connected wind farm for immediate use of the energy (the mine will consume its own energy and thus will require an IRR of 0%). However, data from the 10 m tower should be considered highly uncertain. As noted, the mine has an estimated lifetime of 12 years and the financial analysis shows that wind energy projects are competitive over a longer amortizing period.

In order to have a realistic figure of the wind resource at the Victor Diamond site, it is recommended a wind measurement campaign be carried out, with the appropriate equipment specific to wind energy prospection.

APPENDIX 1

Photographs and Map taken from the Victor Diamond Environmental Assessment Comprehensive Study.