Note – Projet MRC Pierre-de-Saurel

Sujet: Évaluation de la production énergétique du parc éolien – Layout 2
Présenté à: Marcel Fafard
Date: 8 février 2011
Préparé par: **Patrice Ménard et Ève-Line Brouillard, GPCo**

Cette note présente les résultats mis-à-jour de l'estimation de la production énergétique du parc éolien de la MRC de Pierre-de-Saurel, qui a été retenu à l'Appel d'offres communautaire d'Hydro-Québec de 2009.

Le même layout que celui soumis à l'Appel d'offres d'Hydro-Québec A/O 2009-02 (layout2) a été utilisé pour le présent calcul. Le layout 2 a été obtenu selon les coordonnées de 12 turbines fournies par le Groupe SMi le 15 avril 2010 et les calculs d'énergie ont été faits pour 2 hauteurs de moyeu soient 80 m et 100 m. Une année complète de données de mesures brutes a également été fournie par le Groupe SMi. Ces données proviennent d'une tour de mesures se trouvant dans l'aire de projet du futur parc éolien. Le contrôle de qualité de ces données a, quant à lui, été fait par GPCo. La station de référence de Varennes d'Environnement Canada a été utilisée pour faire une corrélation et un ajustement long terme de cette année de données mesurées.

La production énergétique a été obtenue en considérant l'utilisation de turbines REPower MM92, ayant des hauteurs de moyeu de 80 et de 100 mètres. Les spécifications suivantes (fournies par le client en avril 2010) ont été utilisées :

Spécifications techniques de la turbine REPower MM92

Vitesse du vent (m/s)	Puissance (kW)	C_t	Vitesse du vent (m/s)	Puissance (kW)	C_t
0	0	0	13	2050	0.29
1	0	0	14	2050	0.23
2	0	0	15	2050	0.19
3	20	0.98	16	2050	0.15
4	94	0.87	17	2050	0.13
5	205	0.79	18	2050	0.11
6	391	0.79	19	2050	0.09
7	645	0.79	20	2050	0.08
8	979	0.79	21	2050	0.07
9	1375	0.74	22	2050	0.06
10	1795	0.69	23	2050	0.06
11	2000	0.54	24	2050	0.05
12	2040	0.39			

Le logiciel WindFarmer, version 4.1.1.0 a été utilisé pour calculer la vitesse de vent, la perte par sillage ainsi que l'énergie brute relatives à chaque turbine pour chacun des 2 scénarios de hauteur de moyeu considérés.

Layout 2 – 80 mètres

ID Éolienne	Coord. UTM NAD83 O-E (m)	Coord. UTM NAD83 S-N (m)	Vitesse moyenne du vent en régime libre à hauteur de moyeu (m/s)	Pertes de sillage (%)	Énergie brute - sillage* (GWh / an)
1	660320	5094703	5.9	1.7	5.04
2	660955	5094835	5.9	4.5	4.88
3	661444	5094940	5.9	5.1	4.78
4	659236	5093334	5.9	1.4	5.04
5	660015	5093498	5.9	3.8	4.90
6	660736	5093650	6.0	5.8	4.85

ID Éolienne	Coord. UTM NAD83 O-E (m)	Coord. UTM NAD83 S-N (m)	Vitesse moyenne du vent en régime libre à hauteur de moyeu (m/s)	Pertes de sillage (%)	Énergie brute - sillage* (GWh / an)
7	661457	5093803	5.8	5.5	4.64
8	660479	5093064	5.9	5.7	4.84
9	660607	5092493	5.9	5.2	4.86
10	660491	5091993	5.9	5.3	4.84
11	660391	5091462	5.9	5.8	4.83
12	659814	5091166	5.9	3.2	4.95

* La production énergétique « Énergie brute – Sillage » comprend l'effet topographique et les pertes de sillages.

Layout 2 – 100 mètres

ID Éolienne	Coord. UTM NAD83 O-E (m)	Coord. UTM NAD83 S-N (m)	Vitesse moyenne du vent en régime libre à hauteur de moyeu (m/s)	Pertes de sillage (%)	Énergie brute - sillage* (GWh / an)
1	660320	5094703	6.3	1.7	5.73
2	660955	5094835	6.3	4.3	5.56
3	661444	5094940	6.2	4.9	5.44
4	659236	5093334	6.3	1.4	5.70
5	660015	5093498	6.3	3.7	5.59
6	660736	5093650	6.3	5.6	5.50
7	661457	5093803	6.2	5.2	5.35
8	660479	5093064	6.3	5.6	5.51
9	660607	5092493	6.3	5.1	5.52
10	660491	5091993	6.3	5.2	5.52
11	660391	5091462	6.3	5.5	5.50
12	659814	5091166	6.3	3.1	5.64

* La production énergétique « Énergie brute – Sillage » comprend l'effet topographique et les pertes de sillages.

Les pertes additionnelles doivent être prises en compte pour bien estimer la production énergétique potentielle d'un parc. Ces pertes peuvent être regroupées en trois catégories, soient les pertes aérodynamiques, les pertes électriques et les pertes opérationnelles. À partir de toutes ces données, un sommaire des 2 scénarios peut être dressé.

Sommaire de production énergétique du parc éolien

Item	Layout 2 – 80 mètres	Layout 2 – 100 mètres
Modèle d'éolienne	REpower MM92	REpower MM92
Puissance évaluée de l'éolienne	2.05 MW	2.05 MW
Diamètre du rotor de l'éolienne	92.5 m	92.5 m
Hauteur de moyeu de l'éolienne	80.0 m	100 m
Nombre d'éoliennes	12	12
Capacité du parc éolien	24.6 MW	24.6 MW
Vitesse de vent moyenne sur le parc éolien	5.9 m/s	6.3 m/s
Pertes de sillage moyennes	4.4%	4.3%
Production énergétique avant pertes additionnelles*	58.5 GWh/an	66.6 GWh/an
Facteur d'utilisation avant pertes additionnelles*	27.1%	30.9%
Pertes additionnelles	7.8%	7.8%
Production énergétique nette (P50)	**53.9 GWh/an**	**61.4 GWh/an**
Facteur d'utilisation net	**25.0%**	**28.5%**

* Inclus les effets topographiques et les pertes par effet de sillage

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Le tableau suivant présente les résultats de l'analyse d'incertitude sur la production énergétique du projet selon plusieurs seuils de probabilité.

Probabilités de dépassement

Échelle de Prédiction	Seuil de probabilité	Layout 2 - 80 m Production (GWh/an)	Layout 2 - 80 m Facteur de capacité	Layout 2 - 100 m Production (GWh/an)	Layout 2 - 100 m Facteur de capacité
Moyenne 1 an (GWh/Year)	P50	53.9	25.0%	61.4	28.5%
	P75	48.4	22.4%	55.3	25.6%
	P90	43.4	20.1%	49.8	23.1%
	P99	34.8	16.1%	40.4	18.8%
Moyenne 10 ans (GWh/Year)	P50	53.9	25.0%	61.4	28.5%
	P75	50.0	23.2%	57.0	26.4%
	P90	46.4	21.5%	53.0	24.6%
	P99	40.3	18.7%	46.2	21.4%

Le tableau suivant compare les résultats obtenus avec 9 mois de données (résultats de juin 2010) et 12 mois de données (résultats de février 2011) pour une hauteur de moyeu de 80 mètres.

Tableau comparatif (résultats de juin 2010 vs résultats de février 2011)

Item	Juin 2010 WF2 01/09/2009 – 31/05/2010	Février 2011 WF3 01/09/2009 – 31/08/2010
Vitesse de vent moyenne sur le parc éolien	5.8 m/s	5.9 m/s
Production énergétique nette (P50)	**51.5 GWh/an**	**53.9 GWh/an**
Facteur d'utilisation net	**23.9%**	**25.0%**

L'estimation de la production énergétique du parc de la MRC Pierre-de-Saurel est aujourd'hui de 2.4 GWh/an de plus qu'elle ne l'était en juin 2010. Ceci est dû au fait que la vitesse moyenne, au niveau des éoliennes, a augmenté de 0.1 m/s suite à l'ajout de 3 mois de données mesurées et de l'ajustement long terme effectué avec la station d'Environnement Canada de Varennes. L'énergie étant proportionnelle à la vitesse au cube, un petit changement à la vitesse engendre une modification notable à l'énergie.

EXHIBIT 3.6
WIND DATA AND ELECTRICITY GENERATION FORECASTS

FINAL REPORT

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EXECUTIVE SUMMARY

Hydro-Québec Distribution intends to purchase electricity generated by wind farms totalling 500 MW of installed capacity, from two separate blocks of 250 MW each of electricity generated in Québec. These two blocks respectively concern the Aboriginal and community projects. A call for tenders (Call for Tenders A/O 2009-02 [4]) was thus issued on April 30, 2009 that requested proposals by July 6, 2010.

MRC Pierre-de-Saurel proposes to develop the **Pierre-de-Saurel** wind farm with a maximum total capacity of 24.6 MW, for the 250 MW Community block. The site is located near Yamaska in the region of Montérégie, QC.

Wind Turbine Generator Model	WTG Rated Power	Hub Height	Number of WTG's	Wind Farm Capacity
REpower MM92	2.05 MW	80 m	12	24.6 MW

The town of Yamaska is located in the Pierre-de-Saurel MRC, in the Yamaska river valley. It is approximately 15 km southeast of Sorel-Tracy. The "Parc éolien Pierre-de-Saurel" site consists mainly of flat agricultural lands with an average elevation of 20 m.

The site was equipped with one Met mast, which is described in the table below.

Met Mast	Installation Date	Top Anemometer Height	Elevation	Data Collection Starts…	Data Collection Ends…
0091	August 30, 2009	59.0 m	20 m	September 1, 2009	May 31, 2010

The top anemometer height is compliant with HQD Call for Tenders [4] for the proposed turbine hub height of 80 m; in this case the minimum required height is 40 m. The mast measurement period is also compliant with HQD Call for Tenders [4].

During analysis, the quality control process demonstrated that the data quality was acceptable for the Met mast. Data were replaced when instruments on the Met mast were considered to be the equivalent wind measurement. The replacement policy followed HQD Call for Tenders [4] specifications. The **average recovery rate** calculated over the eight month mandatory period is **98.4%** and is compliant with HQD Call for Tenders [4]. The calculation includes the following period: September 1, 2009 to May 31, 2010.

An episodes of instrument malfunction occurred on A3, A4 and A5 between December 24, 2009 and January 10, 2010.

The **wind speed** measured at the mast is **5.5 m/s**. The **winds are dominant from NE, SW and WSW** across the site.

The wind **turbulence intensity** observed at the site is generally **low to moderate**.

Given the land cover and topography at the mast, the **wind shear exponent**, equal to **0.21,** is a little bit high but fairly acceptable.

Met Mast	Annual Average of Measured Wind Speed *	Annual Average of Measured Turbulence Intensity*	Annual Wind Shear
0091	5.5 m/s	9.6 %	0.21

** at Top Anemometer Height*

During the data quality control process, icing events were detected on anemometers and wind vanes. Based on this, it is estimated that **icing** can occur **0.2% of the time** at the site. Given the site elevation and the temperatures associated with these events, it is likely that about 100% of these events will be caused by freezing rain and about 0% will be caused by rime ice. Icing events mainly occur during the months of December and April.

The **air density** was calculated at each mast according to the elevation and the local temperature. The annual value is **1.27 kg/m^3**.

In order to estimate the **long-term wind regime** at the site, several potential **reference stations** with historical data were selected. These were checked in terms of data quality, data availability, climatic similarity with the site, correlation fitness with the Met mast at the site, and other information required to make the best selection among stations.
Based on the above criteria, **Varennes** station monitored by Environment Canada and located 43 km away from the wind farm site, was selected as the reference station for the long term extrapolation of the data. The reference station data were correlated to Met mast 0091 and used to translate the short term data into long term estimates. The long term estimates were then extrapolated from measurement height to hub height.

For the mast location, the wind speed distribution at hub height was used to estimate the number of hours during which the wind turbine would be operational at that mast location (productive hours of wind).

Met Mast	Estimated Long Term Wind Speed at Top Anemometer Height	Estimated Long Term Wind Speed at Hub Height (80.0 m)	Number of Productive Hours of Wind
0091	5.4 m/s	5.8 m/s	7467

The temperature data collected at the mast were used to compute the monthly normal and extreme temperatures after being adjusted to long term with a historical reference station.
The **annual normal temperatures** range **from -10.1°C to 19.8°C**. The **minimum and maximum extreme temperatures** are estimated to be **-32.5°C** in January, and **34.2°C** in June.

The wind resource estimated at the mast was used to compute the wind flow across the project area.
The wind flow was calculated with WAsP software and used to estimate the energy production with WindFarmer software.
The layout was provided by MRC Pierre-de-Saurel and was designed in order to minimise the impact on farm land and to prevent excessive construction costs.

A displacement height value was estimated at each Met mast and turbine location and was used to reduce their effective heights in the wind modeling software.

The net annual energy production anticipated (P50) is presented below. Additional losses include blade soiling, icing, collection network losses, auxiliary power consumption, wind turbines availability, high wind hysteresis, low temperature shutdown, collection network outage and grid availability. On average, it is anticipated that the wind turbines will be unavailable for 22 hours per month for scheduled and unscheduled maintenance.

Wind Turbine Generator Model	Wind Farm Capacity	Net Energy Production (P50)	Net Capacity Factor	Wake Losses	Additional Losses
REpower MM92	24.6 MW	51.5 GWh/year	23.9%	4.4%	7.8%

It is recommended that the measurement campaign be extended at Met mast 0091 in order to better assess the seasonal variations at this site.

Unknowns still remain regarding losses, which contributes to a significant part of the uncertainty on the net energy production forecast. These losses should be reassessed when more information becomes available.

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INTRODUCTION

Hydro-Québec Distribution intends to purchase electricity generated by wind farms totalling 500 MW of installed capacity, from two separate blocks of 250 MW each of electricity generated in Québec. These two blocks respectively concern the Aboriginal and community projects. A call for tenders (Call for Tenders A/O 2009-02 [4]) was thus issued on April 30, 2009 that requested proposals by July 6, 2010.

In this context, GPCo is supporting MRC Pierre-de-Saurel in carrying out a wind resource assessment and in estimating energy production of the proposed Pierre-de-Saurel wind farm, located 4 kilometres south-west of Yamaska in the region of Montérégie, QC, for the 250 MW Community block.

A WIND AND WEATHER DATA

In order to assess the potential of the Pierre-de-Saurel site for wind power development, a wind resource assessment was completed. The site was instrumented with one meteorological ("Met") mast. The installation was done on August 30, 2009. The mast was equipped with sensors at several heights to measure wind speeds, wind directions and temperatures. The analysed data cover a total measurement period of nine months.

This section summarises general information about the measurement campaign, then provides the result of the meteorological data analysis.

A.1 Overview of the Measurement Campaign

A.1.1 Site Overview

The town of Yamaska is located in the Pierre-de-Saurel MRC, in the Yamaska river valley. The mast is approximately 15 km southeast of the city of Sorel-Tracy. The Pierre-de-Saurel site consists mainly of flat agricultural lands with an average elevation of 20 m.

One Met mast was installed in order to assess the wind resource across the project area.

A.1.2 Mast Location

The following table summarises the mast type, the exact coordinates and the elevation of the mast in the project area. Mast 0091 is within the site boundary.

Table A-1: Location of Met Mast (Coordinate System: NAD83)

ID	Type	Diameter (m)	Height (m)	Latitude	Longitude	Elevation (m)
0091	NRG Tubular Mast	0.114	60	N 45° 58' 32.70"	W 72° 56' 30.00"	20

A.1.3 Installation and Collection Dates

The following table provides the date of the mast installation and the period of data collection used in the analysis.

Table A-2: Installation Date and Period of Relevant Data Collection

ID	Installation date	Date and time of first data used	Date and time of last data used
0091	August 30, 2009	September 1, 2009, 12:00 AM	May 31, 2010, 11:50 PM

A.1.4 Instrumentation

The Met mast was equipped with anemometers and wind vanes mounted on booms at several heights. The dimensions of the booms, their heights and orientations on the mast, were designed to comply with the best practices in wind resource assessment as specified in reference [1] and reference [2].

For the met mast, the instrument and mounting characteristics are provided in the table below. All instruments and Met mast undergo regular maintenance checks.

Table A-3: Mounting Characteristics of Instruments at the Met Mast

ID	Type	Height (m)	Orientation	Date Installed	Date Uninstalled	Calibrated / Heated	Primary / Redundant
Mast 0091							
Data Acquisition System							
-	NRG Symphonie	1.7	S	Aug 30 2009	-	-	-
Anemometers							
A1	**NRG #40C**	**59.0**	**W**	**Aug 30 2009**	**-**	**Yes / No**	**P**
A2	NRG #40C	59.0	SE	Aug 30 2009	-	Yes / No	R
A3	NRG #40C	49.5	W	Aug 30 2009	-	Yes / No	P
A4	NRG #40C	38.5	W	Aug 30 2009	-	Yes / No	P
A5	NRG #40C	49.5	SE	Aug 30 2009	-	Yes / No	R
Wind Vanes							
V1	**NRG #200P**	**57.0**	**SE**	**Aug 30 2009**	**-**	**No / No**	**P**
V2	NRG #200P	47.5	SE	Aug 30 2009	-	No / No	R
Temperature Sensor							
T	NRG #110S	2.0	E	Aug 30 2009	-	No / No	P

Note: Lines in bold font correspond to the anemometer and wind vane considered as the principal instruments for wind characterisation at the mast location

A.1.5 Quality Assurance

The entire wind resource assessment process at GPCo is covered by a quality assurance plan. This plan aims to:

- Ensure that all quality control processes are applied;
- Ensure that all the information about the site, installation, equipment, operation, maintenance, data collection and data analysis are collected, assembled, organised and preserved in a standard and useful fashion.
- Demonstrate that, where applicable, the equipment and procedures used in the wind monitoring program comply with national, international and industry standard practices.

Each of the following steps of the wind resource assessment project is developed in accordance with a given procedure:

- Site prospecting and selection;
- Meteorological tower installation;
- Inspection, operation and maintenance, data acquisition;
- Data quality control;
- Data analysis and reporting;
- Tower decommissioning.

The table below describes the procedures for the main steps of the wind resource assessment

Table A-4: Procedures and Control Documents for Wind Resource Assessment

Inspection, Operation and Maintenance, Data Acquisition	
Object	Validate the tower installation Collect Data
Key points	- Installation quality control - Data collection - Proper intervention according to failure types
Control documents	- Field Inspection Form - Quality Control Report - Field Maintenance Order - Field Maintenance Report - Tower Log File
Data Quality Control	
Object	Control the quality of the collected data and identify eventual instrument or data collection failures
Key points	- Data collection, storage and backup - Data validation with analysis of realism, coherency, equipment or data handling failures, environmental effects (shading, icing, etc.)
Control documents	- Data Quality Control Form - Quality Control Tool - Tower Log File
Data Analysis and Report	
Object	- Analyse wind characteristics - Estimate wind energy potential of the site
Key points	- Wind analysis (speed, direction, shear) - Temperature and density analysis - Power and energy density estimation - Wind farm micro-siting process - Wind farm uncertainty and loss analysis
Control documents	- Reporting List - Quarterly Report Check-list - Annual Report Check-list - Micro-siting Data Preparation Checklist - WindFarmer Checklist

A.2 Meteorological Data Analysis

A.2.1 Quality Control

The quality and completeness of data are key factors that determine the reliability of the wind resource assessment.

Data are collected periodically from the Met mast and the quality of the data is analysed. This is done by applying a variety of logical and statistical tests, observing the concurrent readings from different instruments and relating these observations to the physical conditions at the site (e.g. wind shading, freezing potential, etc.). The process is semi-automated: the tests are implemented in a computer program developed by GPCo, but the expertise of quality analysts are required to accept, reject or replace data. There are many possible causes of erroneous data: faulty or damaged sensors, loose wire connections, broken wires, data logger malfunction, damaged mounting hardware, sensor calibration drift, icing events and different causes of shading (e.g. shading from the mast or from any obstacles at the site). A list of the possible error categories used during quality control is presented in Table A-5. Data points that are deemed erroneous or unreliable are replaced by redundant data when available, or removed from the data set.

The data recovery rate for the analysis period is then calculated for each of the instruments using the following equation:

$$\text{Data recovery rate}\,(\%) = \frac{\text{Number of valid observations}}{\text{Number of potential observations}} * 100$$

The "Number of valid observations" is evaluated once erroneous or unreliable data are replaced with available redundant data. The "Number of potential observations" is the theoretical maximum number of measurements that could be recorded during the analysis period. A high data recovery rate ensures that the set of data available is representative of the wind resource over the measurement period.

Table A-5: Error Table

Error Categories
Unknown event
Icing or wet snow event
Static voltage discharge
Wind shading from tower
Wind shading from building
Wind vane deadband
Operator error
Equipment malfunction
Equipment service
Missing data (no value possible)

A.2.2 Data Replacement Policy

Data were replaced when instruments on the same Met mast were considered to be the equivalent wind measurement. Replacements were done directly or by using a linear regression equation. Direct replacement is applied to anemometers when the replaced and replacing instruments are of the same model, calibrated, at the same height, and well correlated. Direct replacement is also applied to wind vanes as long as they are well correlated.

A relatively small percentage of the data set is replaced by equivalent instruments and it is considered to have a negligible impact on the uncertainty of the measurements.

A.2.3 Recovery Rates

The following tables present the recovery rates calculated for each qualified instrument after quality control and after replacements have been completed according to the replacement policy. A "qualified" instrument is an instrument mounted at a height over 50 % of the planned wind turbine hub height (80.0 m) as requested by HQD Call for Tenders [4].

The period used for the mast is specified in Table A-7. This period respects the requirements of HQD Call for Tenders [4]–it represents a minimum of 8 months of observations, including months December to March.

Table A-6: Qualified Instruments Data Recovery Rates

Mast ID	A1	A3	V1
0091	99.8%	97.5%	97.8%

Table A-7: Mandatory Period for Recovery Rate Calculation

ID	Periods of data used
0091	September 1, 2009, 12:00 AM to April 30, 2010, 11:50 PM

The average recovery rate for the Met mast is computed as the average recovery rate of each qualified sensor. The tower recovery rates are then averaged to produce a global data recovery rate. The result is summarised below.

Table A-8: Met Mast Data Recovery Rate

Mast ID	Recovery Rate	Qualified Sensors
0091	98.4%	A1, A3, V1
Global	**98.4%**	

This recovery rate was calculated for the mandatory period quoted in Table A-7.

A.2.4 Wind Conditions

The following table provides the average wind speed and the maximum 2-second gust observed, and specifies the averaging method used and the period of data considered. The averaging method varies as it depends upon the available data set:

- Annual: average of the wind speed recorded over one or more full years.
- Annualised: the annualised wind speed is a weighted wind speed that is calculated from all available monthly average wind speeds–e.g. if 2 values are available for January and only one is available for February, the February value will have twice the weight of each January value in the final average.
- Average: due to insufficient data collection, the annual average wind speed was not calculated. The value given is the average of all available data.

Table A-9: Wind Speed Characteristics at the Mast

Mast	Top Anemometer Height (m)	Period	Average Wind Speed (m/s)	Maximum 2-second gust (m/s)	Method
0091	59.0	September 1, 2009 to May 31, 2010	5.5	25.85	Average

The wind speed frequency distribution is presented below in table for the mast[1]. The frequency distribution graph follows the table.
NB: only valid pairs of wind speed and direction data have been used to build the distributions presented here.

Table A-10: Wind Speed Frequency Distribution Table, Mast 0091, anemometer A1, September 1, 2009 to May 31, 2010

WIND SPEED FREQUENCY DISTRIBUTION																
Wind Speed (m/s)	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Frequency (%)	1.7	3.5	6.4	9.7	12.6	17.2	16.9	12.9	7.9	4.4	3.0	1.7	0.9	0.6	0.3	0.2
Wind Speed (m/s)	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
Frequency (%)	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	

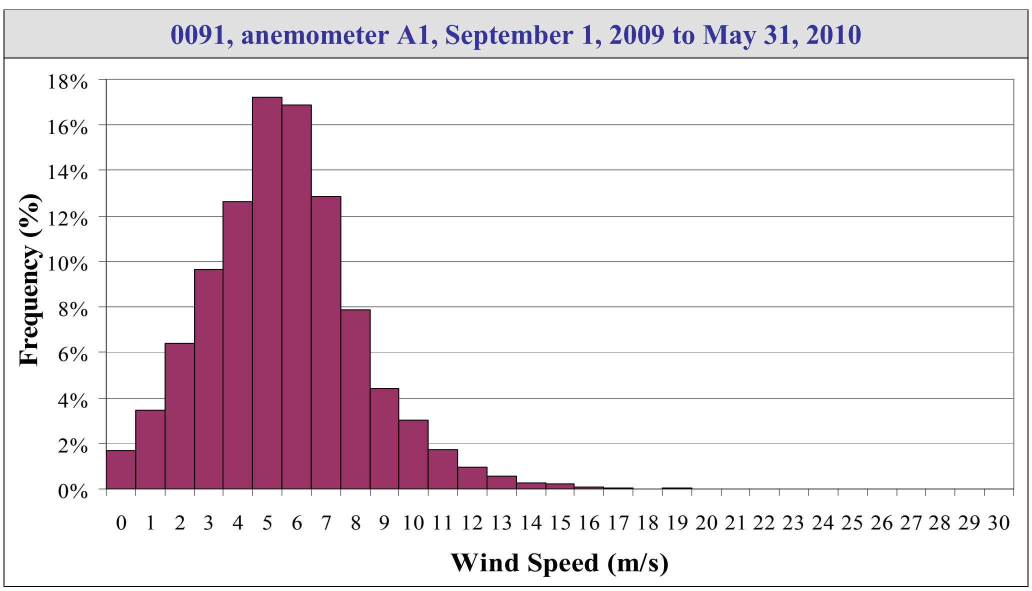


Figure A-1: Wind Speed Frequency Distribution Graph

[1] The 0 m/s wind speed bin indicates the fraction of the total number of measurements with a wind speed between 0 to 0.5 m/s. The other bins are 1 m/s wide and centered on the integer value (e.g.: the 1 m/s wind speed bin indicates the fraction with a wind speed between 0.5 to 1.5 m/s).

The wind rose table is presented below. The corresponding graph follows. The wind rose is divided into the conventional 16 compass sectors (22.5º wide sectors). Note that all compass orientations referenced in this report are based on the true geographic north, rather than the magnetic north.
NB: only valid pairs of wind speed and direction data have been used to build the wind rose presented here.

Table A-11: Wind Rose Table, Mast 0091, September 1, 2009 to May 31, 2010

Mast ID	Wind Direction Frequency (%)															
	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
0091	6.3	9.0	13.3	4.8	2.3	1.9	1.6	1.6	3.5	6.2	12.5	11.4	7.2	5.6	7.1	5.5

0091, September 1, 2009 to May 31, 2010

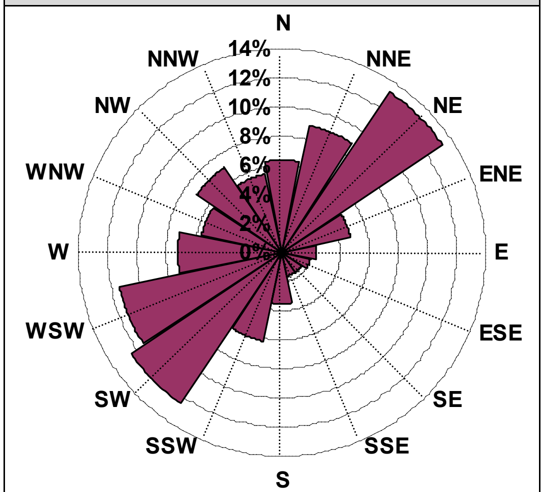


Figure A-2: Wind Rose Graph

The wind rose indicates that a significant proportion of the wind blows from northeast, southwest and west-southwest, across the project area.

The average wind shear exponent is reported in the following table. GPCo actually uses the log law to estimate the wind vertical profile at mast location (a log law curve is fitted through the average wind speeds at the various measurement heights). Wind shear exponent was calculated between the top anemometer height of the mast and a hub height of 80 m.

Note that when there is dense vegetation, the vertical wind speed profile is displaced vertically above the canopy, thereby displacing the level of zero wind speed to a certain fraction of the vegetation height above the ground. The "displacement height" is defined as the height at which the zero wind speed level is displaced above the ground. The displacement height is taken into account in all wind shear estimations.

Based on our knowledge about the vegetation in the area of the mast, this value is a bit high but fairly acceptable.

Table A-12: Average Wind Shear at the Mast

Mast	Period	Wind Shear
0091	September 1, 2009 to May 31, 2010	0.21

The average turbulence intensity is reported in the next table. The value was calculated with the top anemometer data.

This value is considered low according to the reference values defined in reference [2][2]. It is expected that turbulence will decrease with height, as the effect of obstacles and surface roughness will diminish.

Table A-13: Average Turbulence Intensity at the Mast

Mast	Anemometer used	Period	Turbulence Intensity (%)
0091	A1	September 1, 2009 to May 31, 2010	9.6

Contrarily to the average trend at the mast 0091, the winds from northeast and south to southwest have lower turbulence intensity, while the winds from north and east have higher turbulence intensity.

A.2.5 Air Density

Temperature is measured at the Met mast at a height of around 2 m. Based on these temperatures and the standard barometric pressure of 101.3 kPa at sea level, the monthly average air densities were calculated. Note that to correct for changes in atmospheric pressure with height, the calculations account for the site elevation. The values were calculated over the entire analysis period reported in Table A-2.

Table A-14: Average Air Density at the Mast

Mast	Air Density ($kg.m^{-3}$)
0091	1.27

A.2.6 Temperature

In order to estimate the characteristic temperatures at the Met mast location, historical temperature data from Varennes Environment Canada meteorological station, recorded between 1995 and 2009 with an hourly interval, were compared with the temperature data measured at the Met mast. The reference station historical data were then adjusted to reflect the Met mast conditions and extrapolated to the wind turbines hub height. Finally, the average and extreme minimum and maximum temperatures were estimated for the mast location on a monthly and annual basis. The results are presented here.

[2] Low levels of turbulence intensity are defined as values less than or equal to 0.10, moderate levels are between 0.10 and 0.25, and high levels are greater than 0.25. This classification is for meteorological turbulence only; it should not be used in comparison with IEC models. Meteorological turbulence should not be used to establish the wind turbine class.

Table A-15: Average and Extreme Monthly and Annual Temperatures (°C) at Mast 0091, Long Term estimates at a Hub Height of 80 m

	Monthly Air Temperature (°C)												Annual
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Average	-10.1	-8.5	-3.0	5.3	12.7	18.3	19.8	18.9	14.7	7.7	1.4	-5.9	5.9
Min	-32.5	-28.4	-27.7	-15.3	-2.2	1.4	6.9	4.6	-2.7	-6.3	-21.2	-26.5	-32.5
Max	10.6	7.8	20.6	29.5	32.4	34.2	33.8	33.4	31.8	26.5	18.8	15.1	34.2

A.2.7 Icing Events

Icing affects the operation of wind turbines. Icing on any exposed part of the turbine can occur in the form of wet snow (generally associated with temperatures between 0°C to 1°C), super-cooled rain or drizzle (that can occur at temperatures between 0°C to -8°C, but mostly in the upper part of this range), or in-cloud icing (that can occur below - 2°C). Losses during production due to ice occur in several ways:

- Ice accumulation on the blades alters their aerodynamic profile, reducing the power output.
- Nacelle-mounted instruments accumulate ice and give inaccurate readings. The turbine control system may detect a fault condition due to the turbine output being much greater than expected. This expectation is based on the wind speed. As a result, the turbine will be shut down until the ice is removed from the instruments and the turbine is reset.
- Asymmetric icing causes mass or aerodynamic imbalance leading to vibrations. Control systems that sense vibrations will normally shut down when these vibrations occur.

Icing is a complex phenomenon and predicting icing from meteorological conditions is notoriously difficult, requires a good set of observations from a number of meteorology variables, and can be misleading. As no reliable instrument is presently available to detect and quantify icing events for the purpose of estimating their impact on wind energy production, GPCo uses several tests during data quality control to detect icing events: detection of unusual standard deviations or changes with time of wind speeds and directions, comparison of measurements from a heated anemometer and a standard anemometer at the same level, in parallel with the measurement of temperature.

These tests cannot distinguish between the different types of icing, but a rough approximation can be done by utilising the temperature ranges measured during icing events. Therefore, in the following estimate, we will consider two categories: “glaze”, which is assumed to include wet snow, super-cooled rain and drizzle, and “rime ice”, which is assumed to include in-cloud icing and the very low temperature part of super-cooled rain or drizzle. The threshold of -5°C is used to differentiate between rime ice (below -5°C) and glaze (above -5°C).

The following table presents the estimated number of icing events in a month and the type of event assumed to occur in the project area. This estimate is based on the average of icing events detected on the mast during the measurement campaign.

Table A-16: Estimated Hours of Icing Events, September 1, 2009 to May 31, 2010

	January	February	March	April	May	June	
Hours	0	0	0	6	0	0	
Rime	-	-	-	0%	-	-	
Glaze	-	-	-	100%	-	-	
	July	**August**	**September**	**October**	**November**	**December**	**Annual**
Hours	0	0	0	0	0	11	**17**
Rime	-	-	-	-	-	0%	**0%**
Glaze	-	-	-	-	-	100%	**100%**

A.3 Long Term Wind Speed at Hub Height

To forecast the energy production of a wind power plant, wind data that represent the historical wind conditions at the site are required. Unfortunately, wind resource assessments are generally conducted for a limited number of years, often not more than one or two years, which is not sufficient to capture the year-to-year variability of winds. Consequently, it is necessary to translate the measured short term data into long term data. This is done through a correlation/adjustment process that makes reference to a meteorological station where historical data are available.

Moreover, the top anemometers of the Met mast are usually mounted at a lower height than the expected hub height of the wind turbines. The long term data must then be also extrapolated from these anemometer heights to the height of the wind turbine hub.

A.3.1 Long Term Projection

Selecting a reference data set to perform a long term correlation and adjustment is determined by the following process:

- A quality assessment of the potential long term reference stations for the site (history, similarity of the local climate with regards to the meteorology mast climate, etc.);
- A quality assessment of the correlation equations obtained with acceptable long term reference stations.
- A comparison of the long term correlation results obtained with all acceptable reference stations.

Once the reference data set is selected, it is used to adjust the Met mast data to long-term conditions. It can be achieved either by synthesizing non existing years of data at the Met mast site or by applying an adjustment factor to the measured data in order to better reflect the reference period. The process is as follows:

- The measured data from the Met mast is correlated with the reference data set;
- If the correlation parameters meet the synthesis criteria, then data is synthesized at the measurement mast for the complete reference data period; this is referred to as the Measure-Correlate-Predict (MCP) method;
- If the criteria are not met but a good correlation can still be obtained with hourly or daily intervals, then the measured data set is retained but scaled up or down to long term using the reference average wind speed and the correlation equation obtained; this is referred to as the Climatological Adjustment method;
- If no correlation can be clearly established between a reference site and the Met mast site, the measured data stays unchanged.

A.3.1.1 Selection of reference data set

Among the possible set of reference stations, one station was selected and considered suitable for a climatological adjustment of the data at the Met mast. This station is Varennes monitored by Environment Canada (EC). The location of this station is given in the table below.

Table A-17: Identification of the Long Term Reference station

Name	ID	Instruments Height (m)	Latitude	Longitude	Elevation (m)
Varennes	702327X	10	N 45° 43’ 23”	W 73° 22’ 36”	17.9

A.3.1.2 Climatological Adjustment

The climatological adjustment consists of:

- Correlating short term data at the Met mast with short term data at the reference station;
- Using the obtained linear regression equation, Y = m X + b, where X represents the long term average wind speed at the reference station and Y is the estimated long term average at the Met mast;
- Applying a speed-up factor to the Met mast short term data in order to obtain an average wind speed equal to the estimated long term average at Met mast (i.e. Y).

For mast 0091, which only displayed 9 months of data recorded, it was decided to use the Climatological Adjustment method for long term projection.

The wind speed data of the Met mast was correlated to the concurrent wind speed data at the long term reference station Varennes. Acceptable results were obtained with daily average values. The result of the correlation is given in the following table. Linear regression equation is used to compare the data, where *m* is the slope of the equation, *b* is the intercept, and R^2 is the coefficient of determination.

Table A-18: Correlation between Reference Station and Met mast Wind Speeds

Reference Station	Met Mast	Correlation Period		Daily Wind Speed Correlations		
		Beginning	End	m	b	R^2
Varennes	**0091**	2009/09/01	2010/05/31	0.938	1.8	0.82

The regression equation was then used to estimate the long term average wind speed at the mast as a function of the long term wind speed at the reference station. The long term average at Varennes station is 3.8 m/s. It was estimated by averaging all annual averages over the period 1995 to 2009.

Since the hourly correlation with Varennes meteorological station does not respect GPCo standard criterion, it was decided to not synthesize the missing data in order to estimate the long term wind speeds for the months of June to August. On the other hand, the synthesis was only done to split the net energy production forecast per month as mentioned in section B.4.1- Table B-3.

Table A-19: Climatological Adjustment factor at the Met mast

Met Mast	Wind Speed over Correlation Period (m/s)	Long Term Wind Speed (m/s)	Adjustment Factor (%)
0091	5.6	5.4	-2.3

Finally, the 10-minute measured data recorded at the Met mast were scaled by the adjustment factor to reflect the long-term value. In terms of the wind direction data, the data set for the Met mast remained untouched. As a result, the mast has a set of wind speeds and wind directions that are the best estimate of the long term wind regime.

A.3.2 Extrapolation to Hub Height

The wind shear exponent calculated with the measured data at the mast was not directly used to extrapolate the long term data to hub height. This was completed during the wind flow modeling process (see next chapter): the wind data were entered at anemometer height and extrapolated to hub height by the software (WAsP wind modeling program), using the roughness maps. The measured wind shear values were used to control and eventually correct the roughness maps in WAsP.

The data set was then used to calculate the number of "productive hours"-hours per year when the wind speeds are in the useful operating range of the wind turbines (i.e.: 3.0 m/s to 24.0 m/s) at the mast.

The results are presented in the following tables with the monthly long term wind speeds at hub height.

Table A-20: Estimated Long Term Wind Speed and Useful Hours at 80 m Hub Height*

Met Mast	Estimated Long Term Wind Speed at Hub Height (m/s)	Number of Productive Hours of Wind
0091	5.8	7467

* As calculated with measured wind shear

Table A-21: Estimated Long Term Monthly Average Wind Speeds at 80 m Hub Height*

Mast	Wind Speed (m/s)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0091	6.2	6.3	6.4	6.0	5.6				5.3	5.5	5.0	5.9

* As calculated with measured wind shear

B ANTICIPATED ENERGY PRODUCTION

B.1 General Methodology

Met masts provide a local estimate of the wind resource. Met mast locations are chosen based on how representative they are of the project area and especially potential wind turbine sites. However, since the number of Met masts is usually very limited compared to the expected number of wind turbines, it is necessary to build a wind flow map based on these measurements to extend the wind resource assessment to the whole project area.

Wind modeling software, such as MS-Micro and WAsP, are known to produce erroneous wind flows over complex terrain. In this case, GPCo applies a method based on the Ruggedness Index (RIX) to calculate the wind flow for each mast data set while correcting the errors on wind speeds. All produced wind flows are then merged together by a distance-weighting process. Otherwise, wind flows are calculated with each mast data set and simply merged together by a distance-weighting process.

Once the wind flow map is built, it is possible to optimise the size and layout of the foreseen wind farm for the project, and then to calculate the projected energy production. When necessary, wind turbine hub heights as well as Met mast heights are corrected with the estimated displacement height. This is computed to account for the influence of trees on the wind flow (see section A.2.4). These corrections result in an effective hub height for each wind turbine.

The wind flow and energy production are calculated with specialised software that require, apart from the Met masts long term data, background maps that contain the information on topography, elevation, roughness lengths (related to the land cover) and potential obstacles. This is also used in conjunction with the wind turbine characteristics. Finally, wind farm losses must be estimated in order to complete the energy estimate.

The software used to map the wind resource and to calculate the energy production include:

- WAsP Issue 8.03.0020 from Risø for wind resource mapping;
- Wind Farmer Issue 3.6.2.3 from Garrad Hassan for layout optimisation and energy production calculations.

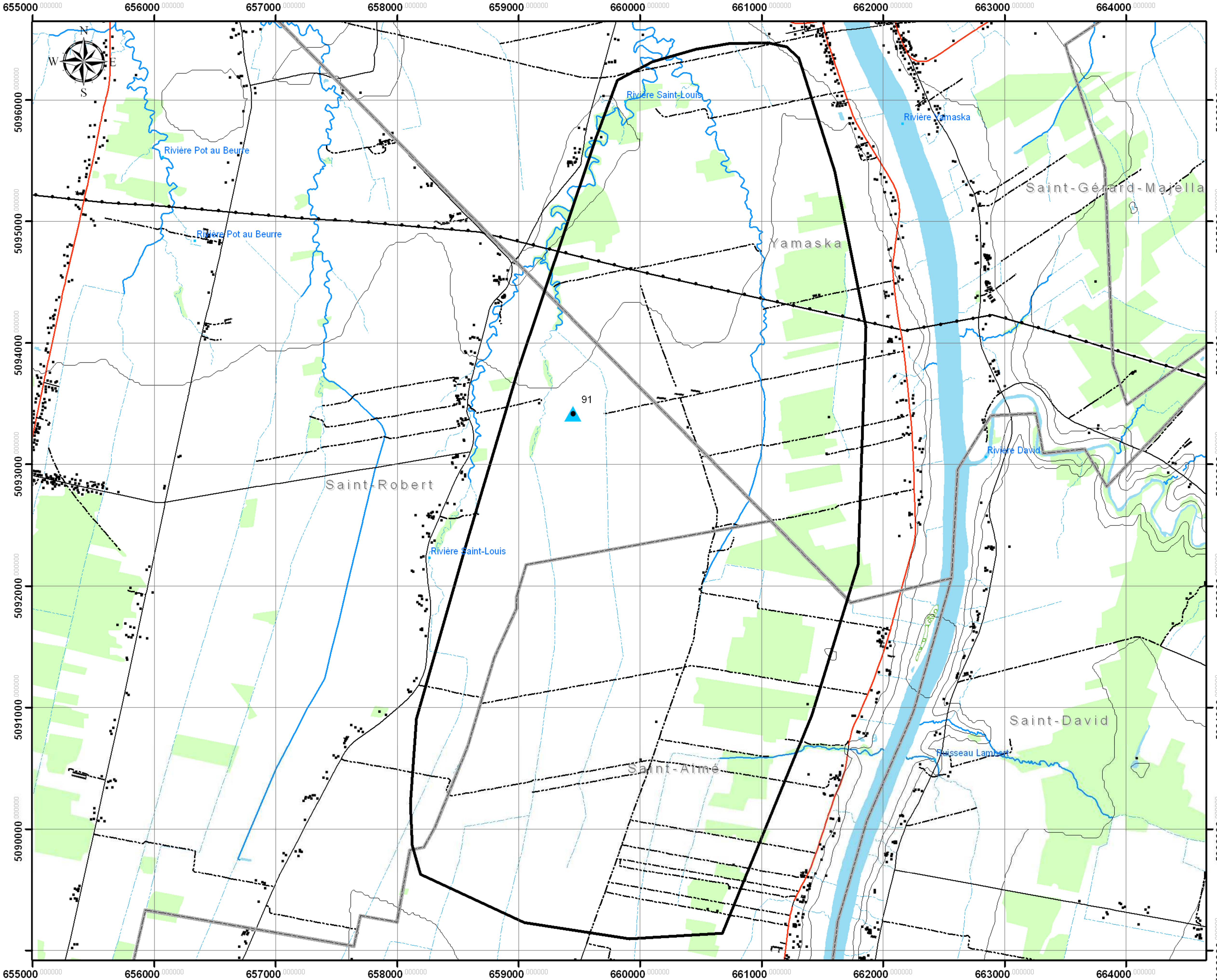
B.2 Background Data

The topographic and elevation data come from BDTQ files provided by the Quebec Topographic Data Base. The contour lines interval is 10 m.

The base map for the roughness lengths was determined from land cover information included in the NTDB files. Around mast location and wind turbines, pictures and information noted during site visits were also used to check the land cover information. The spatial resolution considered for the roughness lengths is 30 m.

No obstacle observed in the project area required specific modelling

The background map, showing topography, contour lines and roughness lengths is provided on next page.



Pierre-de-Saurel Background Map

Legend

- Met Mast
- Building
- Contour (5m)
- Powerline
- Regional Road
- Local Road
- Secondary Road
- River
- Stream
- Municipality
- Project Area
- Wetland
- Lake
- Vegetation

Not for use for plan and construction

0 0.25 0.5 1 Km

1:30,000

Projection UTM - NAD 83 - Z18N

Prepared for:

MRC
Pierre-de-Saurel

Prepared by:

GPCo

27 May 2010

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B.3 Wind Flow Calculation

B.3.1 Terrain Complexity

The wind flow is produced over non complex terrain. Wind modeling software, such as MS-Micro (used in Windfarm) and WAsP, are known to produce erroneous wind flows over complex terrain: Depending on the topography, the predicted wind speeds can be over or under estimated at a given location. Errors can reach more than 20% in very complex areas.

However, in the present case, the complexity of the terrain is considered low enough that the confidence in the modelled wind flow is high.

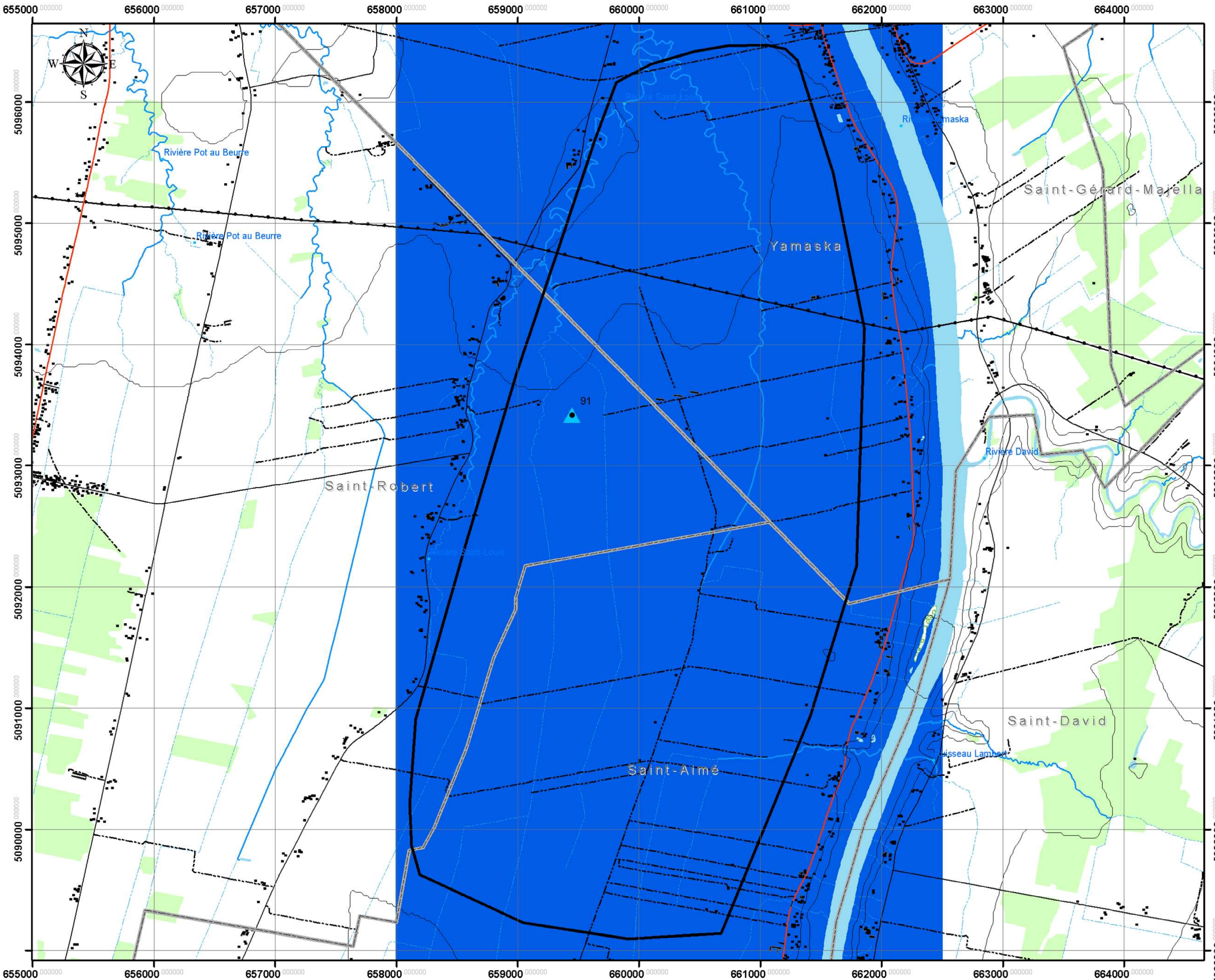
B.3.2 Wind Flow Map

The following parameters were used to calculate the wind flow map.

Table B-1: Wind Flow Calculation Parameters

Parameter	Value
Wind Resource Grid Spatial Resolution	50 m
Calculation Area	10 km by 4.5 km
Met Mast	0091
Reference Height	Top Anemometer Height Corrected for Displacement Height
Calculation height	80 m
Vertical Extrapolation Method	WAsP standard model
Roughness Change Model	WAsP Standard Model

The wind flow map used for energy production estimates is presented on the next page.



Pierre-de-Saurel
Wind Flow 2

Legend

- Met Mast
- Building
- Contour (5m)
- Powerline
- Regional Road
- Local Road
- Secondary Road
- River
- Stream
- Municipality
- Project Area
- Wetland
- Lake
- Restriction
- Vegetation

Windflow (80m)

m/s

- < 5
- 5 - 5.25
- 5.25 - 5.5
- 5.5 - 5.75
- 5.75 - 6
- 6- 6.25
- 6.25 - 6.5
- 6.5 - 6.75
- 6.75 - 7
- 7 - 7.25
- 7.25 - 7.5
- 7.5 - 7.75
- 7.75 - 8
- 8 - 8.25
- 8.25 - 8.5
- 8.5 - 8.75
- 8.75 - 9
- 9 - 9.25
- 9.25 - 9.5
- 9.5 <

Not for use for plan and construction

Wind resource map created by GPCo with WAsP 8.03.0020
Height of calculation: 80 m.
Spatial resolution of wind resource grid: 50 m
Source file: PDS_0091_GRID80m_WF2.grd
Topographic data are provided by the Center for Topographic Information (NRCan). Meteorological data were collected from mast 0091, located less than 1 km from the center of the map, between 01/09/2009 and 31/05/2010. Data were controlled by GPCo, Met data were adjusted for long term with reference to station Env. Can. Varennes #702327X (reference period 1995-2009).
It is believed that the present map gives a reliable overall picture of the wind resource. However, it is advised to confirm any information obtained from this map at any location by on-site measurements.

0 0.25 0.5 1 Km

1:30,000

Projection UTM - NAD 83 - Z18N

Prepared for: MRC Pierre-de-Saurel

Prepared by: GPCo — A member of the Hatch Group

28 June 2010

B.4 Forecasted Energy Production

The layout was provided by MRC Pierre-de-Saurel and was designed in order to minimise the impact on farm land and to prevent excessive construction costs.

The final project layout, Layout_2, is presented on the next page.

B.4.1 Energy production

Once the layout has been provided, the energy production for each wind turbine is calculated. When necessary, wind turbine hub heights as wells as Met mast height are corrected with the estimated displacement height. This is computed to account for the influence of trees on the wind flow (see section A.2.4). These corrections result in an effective hub height for each wind turbine.

The displacement height at each turbine location was estimated using high resolution satellite images. It was validated with photographs taken during site visits and on-site trees height measurements.

The additional losses are described in the next section.
Note that air density is corrected by the software for each turbine location according to its elevation.

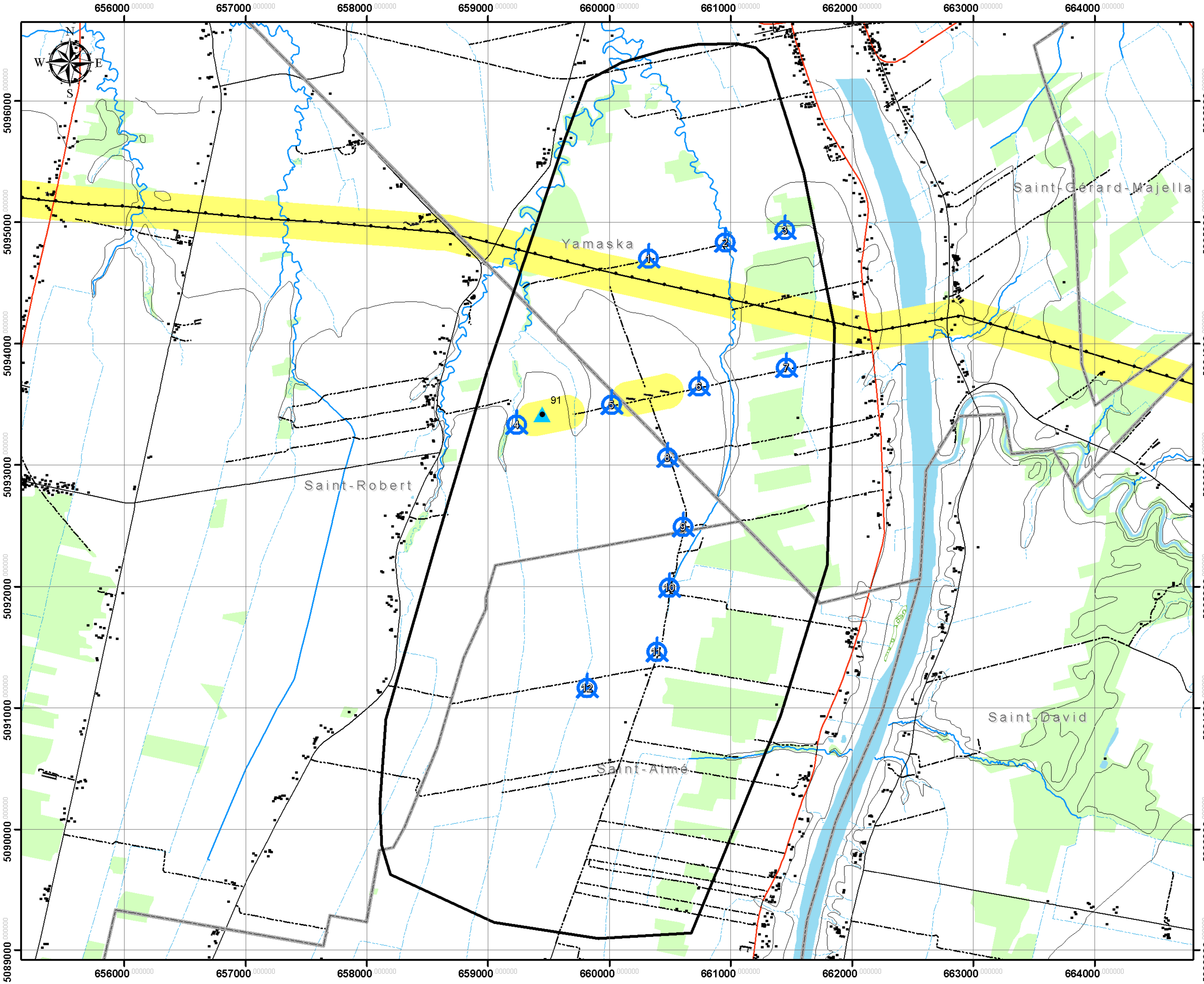
The following table is a summary of the estimated energy production. Detailed figures, by wind turbine, are presented at the end of this section.

Table B-2: Wind Farm Energy Production Summary

Item	Value
Wind Turbine Type	REpower MM92
WTG Rated Power	2.05 MW
WTG Rotor Diameter	92.5 m
WTG Hub Height	80.0 m
Number of Wind Turbines	12
Wind Farm Capacity	24.6 MW
Mean Free Wind Speed across Wind Farm	5.8 m/s
Average Wake Losses	4.4%
Energy Production Before Additional Losses*	55.9 GWh/yr
Capacity Factor Before Additional Losses*	25.9%
Additional Losses	7.8%
Net Energy Production (P50)	**51.5 GWh/yr**
Net Capacity Factor	**23.9%**

* Includes topographic effect and wake losses

Pierre-de-Saurel Layout 2



Legend

- Wind Turbine
- Met Mast
- Building
- Contour
- Powerline
- Railway
- Regional Road
- Local Road
- Secondary Road
- River
- Stream
- Project Area
- Municipality
- Wetland
- Restriction
- Lake
- Vegetation

Not for use for plan and construction

Turbine model: REPower MM92
Number of turbines: 12
Site capacity: 24.6 MW
Turbine rated power: 2.05 MW
Hub height: 80 m
Mean free wind speed at hub height: 5.8 m/s
File reference: PDS_Lay2_positions.txt

0 0.25 0.5 1 Km

1:30,000

Projection UTM - NAD 83 - Z18N

Prepared for: MRC Pierre-de-Saurel

Prepared by: GPCo A member of the Hatch Group

28 June 2010

The following table provides monthly energy production values. The monthly values are based on monthly average wind speeds and monthly average temperatures. Icing losses are also divided between months according to the estimated number of icing events, which are presented in section A.2.7. Losses due to soiling are evenly spread over the summer months and considered null for winter months.

Since meteorological data collection was incomplete for the months of June to August, the average monthly wind speeds and temperatures for these months were synthesized using the data collected from Varennes meteorological station and used to calculate the energy production per month.

Table B-3: Wind Farm Estimated Monthly Net Energy Production Forecast

Net Energy Production Forecast – P50- (GWh)											
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
5.8	6.1	6.1	5.1	4.1	3.1	2.8	2.7	3.4	3.9	3.1	5.2

Table B-4: Forecasted Energy Production at Wind Turbines

Turbine ID	Easting (m)	Northing (m)	Altitude (m)	Effective Hub Height+ (m)	Mean Free Wind Speed (m/s)	Gross Energy Production* (GWh / Year)	Wake Losses (%)	Gross Energy - Wake* (GWh / Year)	Turbulence Intensity** (%)
1	660320	5094703	19	80	5.9	4.91	1.6	4.83	12.1
2	660955	5094835	19	79	5.8	4.87	4.3	4.66	12.7
3	661444	5094940	20	77	5.8	4.82	4.7	4.59	12.7
4	659236	5093334	20	80	5.9	4.87	1.6	4.79	12.1
5	660015	5093498	20	80	5.9	4.90	4.0	4.71	12.5
6	660736	5093650	20	80	5.9	4.91	5.6	4.63	12.7
7	661457	5093803	20	74	5.8	4.68	5.3	4.44	12.7
8	660479	5093064	20	80	5.9	4.89	6.0	4.60	12.9
9	660607	5092493	20	80	5.9	4.89	5.2	4.64	12.7
10	660491	5091993	20	80	5.9	4.90	5.3	4.64	12.9
11	660391	5091462	20	80	5.9	4.91	5.8	4.62	12.8
12	659814	5091166	21	80	5.9	4.91	3.6	4.73	12.4

+ Effective hub height is the hub height minus the displacement height estimated at the turbine location.
* Gross energy production includes topographic effect; "Gross energy – Wake" includes topographic effect and wake losses.
** Turbulence Intensity includes ambient turbulence and incident turbulence. The values represent true meteorological turbulence; they should not be compared directly with IEC models and consequently should not be used to establish the wind turbine class.

B.4.2 Additional Losses

Additional losses include aerodynamic, electrical and operational losses.
The additional losses considered are detailed in the following table and described hereafter.

Table B-5: Additional Wind Farm Losses

Contributor	Losses (%)
Blade Soiling	1.0
Icing	0.1
Collection Network	3.0
Auxiliary power	0.3
Wind Turbines Availability	3.0
High Wind Hysteresis	0.0
Low Temperature Shutdown	0.0
Collection Network Outage	0.5
Grid Availability	0.2
Total*	**7.8**

* The total is the cumulated effect of the different losses and not their direct summation.

Blade soiling refers to the reduction of the blade's aerodynamic performance due to dust and/or insects. A generic figure based on industrial standards is used.

Icing losses happen in different ways: ice accumulation on blades alter their aerodynamic performance, nacelle-mounted instruments affected by ice give inaccurate readings and induce turbine control system errors, asymmetric icing causes mass or aerodynamic imbalance leading to vibrations that may force control systems to shut down the turbine.
Icing losses are estimated from the detection of icing events during Met masts data quality control and translating the icing events into production losses. Figures should be taken with caution since no proven methodology is currently available.

Collection network losses appear in the cables connecting the wind turbines to the substation and in the substation itself. Losses depend on the design of these elements. Cable losses are proportional to the length of the cables. These losses have been roughly estimated by GPCo according to standard figures. They should be confirmed by the developer when the design of the collection network is finalized.

Auxiliary power losses account for various subsystems of a wind turbine that require electrical power, such as control systems or heaters. All of these losses are not always accounted for in the power curve. For example, cold packages designed for cold climate wind turbines can require energy even when the turbine is stopped.
A generic figure is used to account for the consumption of standard auxiliary systems.
Since the specifications for the wind turbine, REpower MM92, used in the present scenario were not available, no other auxiliary power losses were added here.

Wind turbines availability represents the percentage of time over a year that the turbine is available for power production. Losses include regular maintenance time and unexpected turbine shutdowns. A given availability rate is normally guaranteed by the wind turbine manufacturer.

The figures have been estimated according to our knowledge of standard warranty contracts and modern wind turbine maintenance schedules. This gives a total of 263 hours of unavailability per year (22 hours per month) for scheduled and unscheduled maintenance.

High wind hysteresis losses are caused by the control loop of the turbine around cut-out wind speed. They depend on the wind turbine design. These estimations are based on the turbine REpowerMM92 control loop specifications and high wind hysteresis simulations.

In cold climates, turbine shutdowns can be driven by low temperature detection and may happen even if the wind is blowing. The *low temperature shutdown* losses depend on the local climate, the turbine design and the control algorithm. Since the information for the model used in the present analysis was not available, these losses have been estimated by using a low temperature threshold shutdown of -30°C.

The collection network (especially the substation) may be out of service, stopping energy delivery from the turbines to the grid. *Collection network outage* losses include shutdown time for scheduled maintenance and unexpected outages. Figures are generic and based on IEC 61400-1 electrical standards [3], with which the collection network design should comply. They should be confirmed by the developer when the design of the collection network is finalized.

The *grid availability* losses depend on the utility distribution system quality and capacity. It represents the percentage of time over a year when the grid is not able to accept the energy produced by the wind turbines. The figure used is generic and considered standard for modern well maintained utility grids.

Apart from the losses provided here, other aspects have been examined and considered to have a negligible impact on the production. Especially, start-ups, operations while out of alignment, violent winds shutdowns will have no significant impact with modern wind turbines and a correct intervention plan.

C CONCLUSIONS AND RECOMMENDATIONS

C.1 Objectives of analysis

The aim of this report was to present a full wind resource assessment on behalf of MRC Pierre-de-Saurel for the Pierre-de-Saurel proposed wind farm, including the estimation of the forecasted annual energy production for a proposed wind farm layout.

C.2 Data quality and Adjustments

The wind data recovery rates at the monitoring site, for the analysis period, were considered nearly perfect, with a global recovery rate of 98.4%. The data were thus used confidently as it was assumed to represent the analysis period of the site.

However, it is recommended that the measurement campaign be extended for mast 0091 in order to better assess the seasonal variations at this site.

The measured data were adjusted to long term by correlation with Environment Canada's station Varennes, located 43 km away from the project area. The Long Term Adjustment method was applied to do the adjustment. This was considered to be the best method for producing a representative data set for the expected life of the project.

C.3 Wind Resource

The annual average wind speeds at the Met mast are a result of the measurements and the long term adjustment. These wind speed are summarised in the table below for top anemometer and hub heights.

Table C-1: Estimated Long Term Annual Wind Speeds

Mast (Measurement Height)	Estimated Long Term Annual Wind Speed at Measurement Height (m/s)	Estimated Long Term Annual Wind Speed at a Hub Height of 80.0 m (m/s)
0091 (59.0 m)	5.4	5.8

The long term data set at the Met mast was used to build the wind flow across the project area.

It should be noted that there is some uncertainty attached to wind flow modeling. Installing more Met masts, as close as possible to the anticipated turbine locations and for several years, would help reduce this uncertainty.

C.4 Forecasted Energy Production

The main results of the micro-siting exercise for the proposed wind farm are summarised in the table below.

Table C-2: Forecasted Annual Energy Production

Item	Base Case
Wind Turbine Type	REpower MM92 (2.05 MW)
Number of Wind Turbines	12
Wind Farm Capacity (MW)	24.6
Annual Net Energy Production (GWh/yr)	51.5
Net Capacity Factor (P50)	23.9%

Unknowns still remain regarding losses, which contributes to a significant part of the uncertainty on the net energy production forecast. These losses should be reassessed when more information becomes available, particularly in relation to warranty contracts, maintenance schedules and turbines specifications.

References

[1] International Energy Agency Programme, *Recommended practices for wind turbine testing and evaluation – Task 11: Wind Speed Measurement and Use of Cup Anemometer*, 1999

[2] National Renewable Energy Laboratory, *Wind Resource Assessment Handbook*, 1999

[3] International Electrotechnical Commision, *Wind Turbines - Part 1: Design Requirements*, IEC 61400-1, Ed. 3, 2005-08.

[4] Hydro-Québec Distribution, Electricity Supply for Québec Needs – Call for Tenders Document A/O 2009-02, Wind Generated Electricity for a Total of 500 MW Divided as Follows: Block of 250 MW from Aboriginal Projects and Block of 250 MW from Community projects, including:
Consolidated document integrating Addenda 1 and 2 issued on September 11, 2009